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REPORT

OF THE

Agricultural Research Institute and College, Pusa

(Including the Report of the Imperial Cotton Specialist)

1913-14



CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1914

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Report of the Agricultural Research Institute and College, Pusa,

(Including the Report of the Imperial Cotton Specialist)

1913-14.

REPORT OF THE DIRECTOR.

(BERNARD COVENTRY, C.I.E.)

I.—CHARGE AND STAFF.

Charge.—Mr. J. Mackenna, M.A., I.C.S., held charge of the office of Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, till my return from leave on the 23rd February 1914, when I resumed charge of the post.

Mr. A. C. Dobbs held the post of Assistant to the Agricultural Adviser to the Government of India till 28th April 1914, when he was appointed to act as Imperial Agriculturist and Mr. M. Wynne Sayer, B.A., who joined the Department on the 20th March 1914, was appointed to officiate for Mr. Dobbs.

Staff.—The Chemical Section remained in charge of Dr. J. W. Leather, V.D., Ph.D., F.I.C., throughout the year.

Mr. H. E. Annett, B.Sc., F.C.S., F.I.C., Supernumerary Agricultural Chemist, returned from study leave on 28th November 1913, and was appointed Agricultural Chemist to the Government of Bengal on 1st January 1914. Mr. Jatindranath Sen, M.A., F.C.S., First Assistant in the Chemical Section, was appointed Supernumerary Agricultural Chemist on the 9th February 1914.

Mr. A. Howard, M.A., A.R.C.S., F.L.S., Imperial Economic Botanist, and Mrs. Howard, M.A., his Personal Assistant, returned from leave on 19th October 1913. As

in previous years Mr. and Mrs. Howard proceeded to Quetta in May 1914, and will stay there for five months for work in connection with the development of the fruit industry in Baluchistan. During the year under report Mr. Howard was appointed a Companion of the Most Eminent Order of the Indian Empire.

The Mycological Section was in charge of Dr. E. J. Butler, M.B., F.L.S., till the 28th March 1914, when he proceeded on nine months' combined leave.

Mr. F. J. F. Shaw, B.Sc., A.R.C.S., F.L.S., on the termination of his appointment as Officiating Government Mycologist, Madras, resumed his duties at Pusa as Supernumerary Mycologist on the 5th November 1913. He has been appointed to officiate as Imperial Mycologist during Dr. Butler's absence on leave.

Mr. T. Bainbrigge Fletcher, R.N., F.E.S., F.Z.S., joined the post of Imperial Entomologist on 1st December 1913. Previous to his appointment Mr. A. J. Grove, M.Sc., Supernumerary Entomologist, held charge of the Entomological Section. Mr. Grove has been deputed to the Punjab since 28th January 1914, to carry out work on grain pests and cotton bollworm.

Mr. F. M. Howlett, B.A., F.E.S., remained in charge of the Pathological Entomological Section throughout the year.

The Bacteriological Section was in charge of Mr. C. M. Hutchinson, B.A., during the whole year, except for a short period of two weeks from 24th February 1914, when he was on privilege leave and Mr. J. H. Walton, B.A., B.Sc., Supernumerary Agricultural Bacteriologist, officiated for him.

The Agricultural Section was in charge of Mr. S. Milligan, M.A., B.Sc., till 28th April 1914, when he proceeded on one year's combined leave and Mr. A. C. Dobbs took over charge from him.

The number of Supernumerary Agricultural appointments was reduced from three to two during the year under report. Mr. N. S. McGowan, Dip. in Agri. (Cantab.), and Mr. T. Gilbert, B.A., Dip. in Agri. (Cantab.), have been

appointed Deputy Directors of Agriculture in Bihar and Orissa and Bombay respectively. The two Supernumerary posts are now held by Mr. G. D. Mehta, L.Ag., B.A., N.D.A., N.D.D., who has been posted to Madras for training, and Mr. M. Wynne Sayer, B.A., who joined the Department on 20th March 1914.

II.—WORK OF THE INSTITUTE.

Scientific Work.—An account of the scientific work of the Institute during the year is given in the reports of the several sections.

Training.—The training of students in post-graduate courses was continued and short courses were also given in Cattle management and Sericulture.

Four students were under training in Agricultural Chemistry during the year under report. The two students referred to in the last year's report, *viz.*, a private student from Madras and a Government Stipendiary from the Travancore State, completed their training. A private student who was studying for the D.Sc. degree of the Allahabad University worked on a piece of research for eight months in the Chemical Laboratory. A student deputed by the Department of Agriculture, Central Provinces, for training in Agricultural Bacteriology was given a preliminary course of training in Agricultural Chemistry.

In the Entomological Section the student deputed by the Department of Agriculture, Travancore, and the student deputed by the Assam Department of Agriculture referred to in the last year's report completed their training in General Entomology during the year under report.

In the Bacteriological Section the probationary research assistant under the Agricultural Chemist to the Punjab Government who was deputed to this Institute for training continued his course in Agricultural Bacteriology during the year.

In the Agricultural Section a graduate of the Sabour Agricultural College deputed by the Bengal Department of Agriculture is undergoing training in General Agriculture.

Besides the regular students mentioned above, the following officers worked in the Mycological Laboratory during the year :—

Mr. A. C. Tunstall, Mycologist to the Indian Tea Association, for about a week, in September 1913.

Mr. G. H. Alington, I.F.S., Assistant to the Forest Botanist, in January 1914, in connection with tree diseases.

Mr. B. L. Gupta, B.Sc., Professor of Biology in the Reid Christian College, Lucknow, attended the Laboratory during May and June 1914, and received a course of lectures and practical work on the morphology of fungi.

During the year under report, seven students attended the short courses—one in "Cattle Management" and six in "Sericulture." Besides the regular students, three visitors were given practical instruction in sericulture and silk-dyeing.

III.—PUBLICATIONS.

The Agricultural Journal, Scientific Memoirs and Bulletins continued to be issued during the year. With a view to keep down the free distribution list and also to encourage Agricultural Associations, Co-operative Societies, students of Agricultural Colleges and Assistants in the Agricultural Departments, specially reduced rates of subscription for the Journal and Memoirs and Bulletins were sanctioned during the year. This has led to a substantial increase in the number of subscribers. With a view to economy steps were taken to supply persons and institutions on the free distribution list with reprints of articles on the special branches of agriculture and its allied sciences in which they are interested in lieu of the Journal. Arrangements were also made during the year for making the Department's publications available for sale at principal centres in various parts of the country.

The Department published during the year 16 Memoirs and 7 Bulletins. In the Veterinary Series of Memoirs

started in April 1912 no less than 8 papers have been published during the course of two years and the number promises to increase in the near future. As regards other series of memoirs a good number of papers were published in the Botanical and Chemical Series to which the Provincial Departments have also contributed.

There is a steady increasing demand from the Indian public for Bulletins as they are mostly of practical interest. As a result Bulletin Nos. 28 and 29 on Lac and Eri silk culture have been reprinted and the Government of India have authorised the Agricultural Adviser to increase in future to 2,000 copies bulletins for which there is likely to be a good demand.

The grant for publications as at present sanctioned is Rs. 29,000. During the last two years greatest economy had to be exercised to keep the expenditure within the sanctioned grant. The rates both for letter-press printing and reproduction of illustrations have been recently revised. Papers received are also carefully scrutinised and all illustrations not absolutely required are eliminated. But as the investigation of problems is yearly on the increase the volume of matter offered for publication is anticipated to become larger each year and it will soon be necessary to ask for a further addition to the grant.

IV.—GENERAL ADMINISTRATION.

Buildings and Works.—During the year under report the Government of India sanctioned the construction of eight additional quarters for the subordinate staff of the Institute. The extension of the Director's office building referred to in the last year's report was completed during the year. Proposals have been submitted to Government for the installation of electric lights and fans in the European bungalows and the Guest House at Pusa, and for the addition of a Female Ward to the Pusa Hospital.

Library.—The third edition of the catalogue of the library is in the press and will shortly be out. During the year under report over 500 volumes have been added by purchase besides several foreign bulletins, memoirs, reports,

etc., which are received in exchange from different parts of the world.

Pusa Middle English School.—The Pusa Middle English School which was established in 1912 is becoming popular. It has four English and four Vernacular classes and the total number of boys on the roll is 93 out of which 53 belong to the Estate and the remaining 40 come from the neighbouring villages. The school is located temporarily in the Students' Hostel until the completion of the school building which is under construction. Proposals for raising the present school to the status of a High School and also for the establishment of a Girls' School at Pusa are under the consideration of the Local Government.

General Health of the Station.—The general health of the station during the year under report was on the whole very good. Relief was afforded to 9,226 cases, of which 8,999 were treated in the out-patients' department and 227 admitted as in-door patients. One hundred and two cases amongst European officers and families were attended to. The daily average number of patients treated was 64.05 out-door, and 10.69 in-door.

Four deaths occurred in hospital, one from Gangrene-foot, one from Malarial Cachexia, one from Cirrhosis Liver and one from Suppurating Tonsilitis.

The number of Estate cases treated for Malarial Fever was small when compared with the admissions from the neighbouring villages. This was probably due to the Estate people willingly taking the quinine which was issued prophylactically towards the close of the monsoon. An epidemic of cholera which broke out in the villages in the immediate vicinity of Pusa, during the months of April, May and June, threatened to be a source of grave danger. Immediate and successful measures were taken to prevent it entering the Estate. Chief of these was keeping of the water supply pure by disinfecting and cleaning the wells. The epidemic was thus kept out of the Estate limits.

Two hundred and five surgical operations were performed of which nineteen were major, and one hundred and eighty-six minor.

Nine primary vaccinations and three re-vaccinations were performed during the early part of the year.

V.—ACCOUNTS.

The total expenditure during the financial year 1913-14 was Rs. 4,72,471 as under:—

	Rs.
Office of the Agricultural Adviser to the Government of India and Director of the Institute	2,14,158
Chemical Section	38,455
Mycological Section	37,388
Entomological Section	33,942
Pathological Entomological Section	26,749
Botanical Section	27,854
Bacteriological Section	29,171
Agricultural Section	64,754
	<hr/>
	4,72,471

The budget of the Agricultural Adviser for the year under report included a portion of the grant of Rs. 1,10,000 referred to in previous year's report for meeting the expenditure in connection with the engagement of Mr. W. Hulme as Sugar Engineer in the United Provinces for the development of the Indian Sugar Industry. The engagement of Mr. Hulme was sanctioned in the first instance, for three years from 1911-12. It has been decided to retain his services for a further period of two seasons and the expenditure during the current year will be met from the saving in the grant of Rs. 1,10,000 made for the purpose.

A sum of Rs. 15,000 was provided in the budget for payment to the Indian Tea Association as a grant-in-aid.

Out of the sum of Rs. 60,000 allotted during the year ending 31st March 1914, by the Government of India, for improvements connected with the Pusa Institute, Rs. 14,254 were transferred to the Public Works Department Budget for meeting the cost of extension of the Pusa Library and Rs. 25,000 paid towards purchase of steam cultivating machinery for the Pusa Farm. The balance was spent on

testing the milling and baking qualities of wheat, the bacteriological investigation of rice, the demonstration of improved methods of refining saltpetre, experiments with cotton and plant breeding by the Imperial Cotton Specialist, construction of a Potculture house for the Imperial Mycologist, an additional Laboratory for the Imperial Pathological Entomologist and the improvement of the drainage of the low-lying portions of the Pusa Estate.

The gross receipts during the year from the sale of farm produce, milk, publications of this Department and other articles, amounted to Rs. 22,157 as against Rs. 14,663 of the preceding year.

VI.—VISITORS.

In response to the invitation of Mr. J. Mackenna, Lord Islington, Sir Valentine Chirol, Sir Theodore Morison, Messrs. Sly, Scott and Fisher of the Royal Commission on Public Services in India visited the Institute on the 17th January 1914.

During the year under report the Hon'ble Sir Robert Carlyle, K.C.S.I., C.I.E., I.C.S., Member-in-charge of the Department of Revenue and Agriculture, Government of India, the Hon'ble Sir Edward Maclagan, K.C.I.E., C.S.I., I.C.S., Officiating Revenue Member, the Hon'ble Mr. L. J. Kershaw, C.I.E., I.C.S., Secretary to the Government of India, Department of Revenue and Agriculture, Colonel E. H. Hazelton, F.R.C.V.S., A.V.S., Principal Veterinary Officer in India. Mr. M. J. Cogswell, Controller of Printing, Stationery and Stamps, Professor Wyndham R. Dunstan, M.A., LL.D., F.R.S., Director, Imperial Institute, London. Professor Brück of Griessen University, Germany, Mr. M. A. Yamada of the Agricultural Experiment Station, Formosa, Chev. Dr. G. Goric, Consul for Italy, Bombay, and many others visited the Institute.

REPORT OF THE IMPERIAL AGRICULTURIST

(A. C. DOBBS, B.A.)

I.—ADMINISTRATION AND TOURS.

Charge.—Mr. Milligan held charge of the Pusa Farm for the first ten months of the period under review; he went home on long leave at the end of April, after which the writer officiated for him.

The number of Supernumerary Agricultural appointments was reduced from three to two during the year under report. Messrs. Gilbert and McGowan vacated their posts on the supernumerary establishment, on the creation of new appointments on the regular cadre in Bombay and Bihar, and one of the resulting vacancies was filled by the appointment of Mr. M. Wynne Sayer who arrived in India at the end of March, and is now officiating as Assistant to the Agricultural Adviser.

The other post vacated was absorbed in one of the new posts on the regular cadre, while the second remaining Supernumerary appointment continues to be held by Mr. G. D. Mehta, now working in Madras.

Mr. Judah Hyam was in charge of the Breeding Herd throughout the year.

Mr. Mohamed Ikramuddin held the post of 1st Farm Overseer during the year, in addition to the duties of the 2nd Farm Overseer from 16th May 1913 to 4th November 1913.

Mr. Arjan Singh, Agricultural Assistant, Lyallpur Farm, was posted to the vacant post of 2nd Farm Overseer on the 5th November 1913.

Training.—The following students attended the courses:—

1. Mr. B. M. Valweker, from Mysore State, in cattle management, from 29th January 1914 to 4th April 1914.

2. Mr. Kali Prosanna Roy was sent by the Bengal Government for agricultural training at Pusa.

Tours.—Mr. Milligan visited Dacea and Sabour Farms with the Officiating Agricultural Adviser to the Government of India, in August; and Poona, Bombay, Ahmedabad and Umballa to see dairies in September 1913. He also attended the meetings of the Board of Agriculture at Coimbatore in December 1913 and gave evidence before the Public Services Commission on behalf of the Imperial Department of Agriculture, at Bombay during February 1914.

II.—FARM CULTIVATION.

Character of the season.—The rains began with 7 inches in May 1913. The monsoon was characterised by well distributed rainfall throughout, with very heavy falls in June and August. The paddy crop was considerably damaged by floods owing to the defective draining of the Estate. Three-fourths of an inch of rain in the middle of October and again in the middle of December, ensured heavy *rabi* crops, which, however, suffered severely from a similar fall accompanied by strong wind in the middle of February.

Crop Experiments.—The experiments mentioned in last year's report have been continued.

Cultivation.—A Fowler's double engine steam cultivation tackle was obtained in September 1913 with a disc plough, cultivator, harrow, and roller.

The object of this new departure was not only the study of the economics of steam cultivation, but also to enable the Agriculturist to deal more effectively with the labour difficulties incidental to the intensive cultivation, by means of hired labour, of so large an area as is necessary to support the Pusa herd of Montgomery Cattle.

The farm is not an ideal one for steam cultivation, being intersected by public roads which cut it up into irregularly-shaped fields, but by taking the whole available area, squaring up some of the fields, and abandoning odd corners, it will be possible to eliminate most of the land that cannot be

ploughed by steam tackle and yet to leave a sufficient area to employ the tackle to the limit of its capacity. There will still, however, be some waste incurred in moving over considerable distances from field to field.

III.—LIVE-STOCK AND POULTRY.

Breeding Herd.—As may be inferred from the reference above to the herd of Montgomery cows, this herd has become the pivot on which the policy of the farm turns.

Started originally with the idea of preserving and typing the Montgomery breed, and incidentally providing the officials collected at Pusa with a pure milk supply, the herd has grown with the expansion of the Institute and the growing demand for milk from the large number of inhabitants of the estate,—until it has taxed the capacity of the farm to provide sufficient fodder for both the working bullocks and for the breeding herd.

A partial solution has been found in the purchase of the steam tackle, and it is proposed at the same time to grade up the milk producing power of the herd by crossing the poorest milkers with an Ayrshire bull.

The product of this cross has been demonstrated by the Military Dairies in Northern India to be exceedingly useful, the heifers giving milk in amounts comparable with those given by Ayrshire cows, while the bullocks make excellent work cattle.

There will therefore be maintained at Pusa, henceforth, two herds; one of selected milkers of the Montgomery breed; the other a herd of cross-bred Ayrshire-Montgomery cattle which will, it is hoped, take its part in a comprehensive scheme for improving the dairy cattle of India by cross breeding.

Should a considerable development of one or both of these breeds be justified later on, it will be possible to increase considerably the number of breeding cattle at Pusa, owing to the economy of fodder effected by the use of the steam tackle instead of bullocks for cultivation.

Sheep.—The advantage of crossing Dumba rams with the local sheep for the production of mutton having been demonstrated, breeding for mutton has been given up, and an attempt is being made to improve the wool of the local sheep by crossing with Merinos, as mentioned in last year's report.

Poultry.—In view of the general interest now evinced in poultry keeping in the Provinces it has been decided to limit the functions of Pusa to the importation of pure bred birds to maintain the breeds kept on Provincial farms. The Assistant to the Agricultural Adviser to the Government of India is in touch with breeders at home and is prepared to give his advice or assistance to intending importers. No poultry are now kept at the Pusa Farm.

IV.—GENERAL.

All the available farm land has been brought under cultivation.

Manuring with superphosphate has become part of the routine practice of the farm as a result of the proof of the economic value of that manure in the experimental plots.

Considerably better crops have been obtained in recent years and with the high cultivation now rendered possible an economic necessity is beginning to appear of growing more valuable crops, or varieties with sufficient strength of root and stem to support a higher yield than any obtainable from the varieties now available.

V.—PROGRAMME OF WORK FOR 1914-15.

The following are the lines of work in progress :—

Major investigations.

1. The economics of cultivation by steam and motor engines.
2. The puddling of rice land by the double engine system of steam cultivation.
3. The combination of irrigation and drainage in the growing of rice.

4. A study of inheritance of the more important characters of dairy cattle by crossing.
5. The building up of milk pedigree in cattle by selection.

Minor investigations.

6. The inheritance of wool characters in sheep.
7. Experimental tillage in the growing of maize and sugarcane.
8. Improvement of pastures.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST.

(J. WALTER LEATHER, V.D., PH.D., F.I.C.)

I.—ADMINISTRATION AND TOURS.

Charge.—The section was in the charge of myself during the whole year.

Establishment.—Mr. H. E. Annett, Supernumerary Agricultural Chemist, returned from study leave on 28th November 1913 and was appointed Agricultural Chemist, Bengal, on 1st January 1914.

Mr. Jatindranath Sen, First Assistant in this section, was appointed Supernumerary Agricultural Chemist (probationary) on February 9th, 1914.

Mr. Jatindra Nath Mukerjee, Second Assistant, was appointed First Assistant on 9th February 1914.

Mr. A. V. Iyer, a former assistant of this section and latterly Assistant Agricultural Chemist, Sabour, was appointed Second Assistant on 2nd July 1914.

Babu Har Dyal Singh, a junior assistant, was transferred to the Bacteriological Section on 25th May 1914.

Babu Shasanka Bhushan Roy, L.A.G. (Sabour), was appointed (probationary) to the vacant assistantship on 23rd June 1914.

Tours.—The following tours were made by me:—

1. August 1913. To Meerut and Delhi to discuss the value of certain fodder grasses and grass lands with the Assistant Director of Grass Farms. To Roorkee where I discussed the construction of certain instruments with the Superintendent, Canal Foundry and Workshops. To Cawnpore where I examined the condition of certain lands which had been broken up with explosives.

2. October 1913. To Peshawar to inspect the sugar-beet crops and to arrange for the prospective tests of sugarcane and sugar-beet at Tarnah.
3. December 1913. To Coimbatore to attend the meeting of the Board of Agriculture.
4. January 1914. To Peshawar to inspect the work of the assistant who had been posted there to test sugarcane and beet.
5. March 1914. To Bareilly to discuss the practicability of the small factory for sugarcane and sugar-beet with the Sugar Engineer.
6. April and May 1914. To Peshawar, (i) to inspect the work on sugar-beet and to discuss the data with the Agricultural Officer; (ii) to take samples of soil from the Upper and Lower Swat River Canals. To Lyallpur to act as a member of the Board of Examiners at Agricultural College.
7. June 1914. To Peshawar on account of sugar-beet analyses.

II.—EDUCATION.

Four students have been under instruction during the year. One Government and one private student completed their full courses: one Government student has completed the course (one year) specially prescribed for him. One private student who was studying for the D.Sc. degree, Allahabad, worked here for eight months on a piece of research.

III.—METEOROLOGY.

In addition to the usual data which are recorded daily on behalf of the Meteorological Department, records of (a) soil temperature, (b) drainage, and (c) pressure by means of a barograph have been maintained.

IV.—SOIL PROBLEMS.

Drainage.—The records of drainage are maintained and it is probable that another collection of data will be published early next year.

Lime and Magnesia.—The relationship between the amount of gaseous carbonic acid in soils and the amounts of lime and magnesia in solution has been the subject of an investigation which has been conducted by Mr. Sen and myself. The first section of the work was published in 1909 and dealt with the relation between calcium carbonate and gaseous carbonic acid. The second section dealt with the corresponding relationship of magnesium carbonate and carbonic acid. Following this we ascertained the solubility of the two carbonates when present together and also of dolomite under like conditions. It then transpired that if magnesium carbonate is present in anything more than quite small quantities, calcium carbonate becomes practically insoluble. Dolomite was found to dissolve as a double salt in carbonic acid, but the maximum concentration which we could obtain was smaller than was anticipated from a consideration of the other work. The presence of either calcium carbonate or magnesium carbonate was found to protect dolomite from the action of carbonic acid. Magnesium carbonate protects it practically entirely, because it rapidly forms a solution of bicarbonate so concentrated that no appreciable amount of calcium carbonate can dissolve in it and hence the dolomite cannot dissolve. Calcium carbonate does not protect it quite so perfectly, but this salt rapidly forms, in contact with carbonic acid and water, a solution of bicarbonate so strong that little or no more calcium carbonate can dissolve in it and hence the dolomite can only dissolve to a limited degree.

This work has shown that no fertile soil can contain material proportions of magnesium carbonate, for if it did, the lime would become practically insoluble and the plant would die of lime starvation. This is probably the reason why in so many of the experiments which have been made in Europe and America on Loew's lime-magnesia ratio in

soils, the application of magnesite or magnesium carbonate has proved so harmful. The details of this investigation have been published as *Memoirs of the Department of Agriculture in India, Chemical Series*, Vol. III, No. 8.

Swat River Canals land.—A number of samples of soil from the land which has been irrigated by the Lower Swat River Canal and from the land which will come under the Upper Swat River Canal were taken during April and May by the Superintending Engineer and myself from places, the exact position of which has been registered with reference to certain bench-marks on the canals. This latter was done in order that samples may, if desired, be taken from the same places on a future occasion. The original object of taking the samples was to supply information respecting the soil to an engineer in England who has asked for information respecting the chemical composition of these soils. In addition to this, however, Mr. A. J. Wadley, the Superintending Engineer, was himself interested in the subject, and the series of samples was for this reason somewhat increased.

The lands which are commanded by these two canals are very similar, in that they consist of the alluvium which lies at the foot of the Himalayas in this part of India, and although close to the low hills, and indeed some of the isolated outcrops occur in the alluvium, it consists almost entirely of fine alluvium without stones. The land which will come under the Upper Swat River Canal lies close to the hills; that which has been irrigated by the Lower Swat River Canal lies further south. Only certain items in the composition of the soils were determined, those indeed which are most likely to indicate their agricultural value or defects. In respect of *calcium carbonate*, this constituent varies within wide limits, being as high as 10 per cent. or more in four samples and as low as .04 per cent. in three. Usually there is a sufficiency for agricultural purposes, but when the proportion falls as low as .04 per cent. it will probably pay to add lime. Of *phosphate* in a readily assimilable condition there is in some cases a deficiency.

and it is very probable that if artificial manures are ever used in India generally, it will pay to use superphosphate on some of these lands. Of *potash* there is an abundance, whilst of *organic nitrogenous matter* there is the same deficiency that is so common to Indian soils. Respecting their physical condition they are generally good.

A question was incidentally raised as to whether the lands under the Lower Swat River Canal had deteriorated at all. So far as one can tell from these samples, and they were taken from widely separated places, there was nothing to indicate that any depreciation has occurred, and in fact generally these were richer and better than those from the other area.

The Percolation Test for soils.—Some years ago I devised a method for testing the permeability of soils to water. Its immediate object was then the differentiation of certain *usar* soils of the United Provinces.

During the past year a long series of tests with it have been applied to good agricultural soils in order to ascertain its more general applicability. The test appears to make a sharp differentiation between soils which are physically good or bad respectively. The information which has been gathered on the subject will be submitted for publication shortly.

V.—SALTPETRE.

The experiments on improvements in the saltpetre refining process advanced a stage this year. A filter press was obtained from Europe which has shown itself able to deal with the mud very expeditiously. The pumps supplied with the press were, however, defective and another mode of applying the liquid to the press will now be tried.

In the meantime the solubility relations of the chief salts which are present have been worked out by Babu Jatindra Nath Mukerjee and myself and published as *Memoirs of the Department of Agriculture in India. Chemical Series*, Vol. III, No. 7.

VI.—SUGAR.

The work of this section on sugar has been confined to a series of investigations at Tarnab Farm, North-West Frontier Province.

Reference was made in my last Annual Report to the tests of the sugar-beets which Mr. Robertson Brown had grown, and to the fact that the quality of the roots had proved to be very good.

It has been evident throughout in respect to this crop, that the subject must be considered from the manufacturing standpoint, because of the fact that marketable sugar could only be produced from the beet root in a factory. This alone necessitates a regular supply of roots over at least several months because otherwise a factory could not hope to pay. It followed therefore that the next desirable step in the work was to ascertain over how many months this crop could be satisfactorily produced. Mr. Brown agreed in this view and decided to sow plots of sugar-beet at intervals over several months.

A consequence of this decision was that arrangements had to be made for the testing of the crops over a considerable period, and it was therefore decided to take this opportunity of also testing the local sugarcane as also other varieties of cane at the Tarnab Farm in as thorough a manner as possible.

A third investigation now presented itself. It is customary in that locality to bury sugarcane in December in order to preserve it for planting out in the following April. The crop is all harvested in December and January, and cane could not be suitably left standing in the field until the succeeding time of planting. The method of preserving the cane in "clamps" is therefore adopted, and for the end in view the method is very perfect. The question then occurred, does cane, which is preserved in this manner, deteriorate from the manufacturer's standpoint? We decided therefore to include some tests on this question. The investigations had thus to do both with cane and beet.

Sugarcane.—There is a considerable area of sugarcane in the Peshawar Valley, which consists principally of a "thick" variety, yielding heavy crops. A number of samples, each consisting of about 200 canes, were tested in December and January and the following examples illustrate the general quality:—

Date.	Village.	Juice per cent.	IN JUICE.			
			Brix.	Sucrose per cent.	Glucose per cent.	Coefficient of purity.
28-11-13	Tarnab	76.71	14.87	12.03	1.92	80.9
2-12-13	Zakki	74.72	15.40	12.24	2.27	79.5
15-1-14	Tarnab	76.92	15.60	13.10	1.67	84.0
19-1-14	Tarnab	77.65	15.90	13.65	1.49	86.1
3-2-14	Tarnab	...	16.10	13.89	1.39	85.0

The proportion of juice was obtained by crushing the cane in a Nahan bullock power mill. It will be seen from the above examples that it is a cane containing a high proportion of juice. United Provinces canes for example yield only some 60—65 per cent. juice to such a mill. The percentage of sugar in the juice is rather low. As the season advances the quality improves. From the manufacturing standpoint the comparatively low percentage of sucrose is made up for in a great measure by the high proportion of juice and low fibre content which reduces the necessary maceration. The crushing season is limited to the months December and January.

Other canes tested were imported varieties grown at the Tarnab or Haripur Farms, e.g., Striped Mauritius, Purple Mauritius, Saharanpuri, Partabgarhi, etc., most of which proved to be similar in quality to the local *pounda*.

"Clamped" cane.—The method of "clamping" sugarcane in the Peshawar Valley is similar to that employed in Europe for preserving roots or potatoes. It may be

briefly described. The cane is taken up with the surface roots, leaves and tops intact. The canes are placed on the ground in a neat flat heap, canes lying parallel to one another, and covered with about 6" of earth; they then remain undisturbed until the planting season in April. Two experiments were made in order to ascertain whether the cane depreciates when kept in "clamps"—the one was made early in December when four lots of cane, each of about 4.5 maunds, were put in "clamps," the cane being very carefully sampled* and tested at the time; the other was made on January 15th, when two lots of about 9 maunds each were clamped. The cane which was "clamped" in December remained for 21 days in the "clamp;" that of January was left until May and was tested at intervals of about one month. The data obtained are collected in the following statement:—

Composition of sugarcane before and after clamping.

Variety.	Date of putting in clamp.	Date when tested.	JUICE.				
			Juice per cent.	Brix.	Sucrose per cent.	Glucose per cent.	Coefficient of purity.
Striped Mauritius.	24-11-13	...	65.78	14.27	10.84	2.22	76.12
		15-12-13	67.27	14.10	10.60	1.92	75.19
Striped Mauritius.	26-11-13	...	71.96	15.09	12.11	1.61	80.27
		17-12-13	69.14	14.06	11.33	1.82	77.29
Local pounds	28-11-13	...	76.71	14.87	12.03	1.92	80.93
		19-12-13	71.73	15.09	12.09	1.92	80.10
Local pounds	2-12-13	...	74.72	15.40	12.24	2.27	79.50
		21-12-13	67.78	15.13	12.11	2.08	80.05

* For a discussion of errors in sampling sugarcane see *Mem., Dept. Agric., India, Chemical Series*, Vol. III, No. 4.

Composition of sugarcane before and after clamping—contd.

Variety.	Date of putting in clamp.	Date when tested.	Juice per cent.	JUICE.			
				Brix.	Sucrose per cent.	Glucose per cent.	Coefficient of purity.
Local pounds	15-1-14	...	76.92	15.60	13.10	1.67	83.99
		16-2-14	76.31	15.20	12.22	1.85	80.37
		24-3-14	72.50	15.40	12.82	2.04	83.22
		24-4-14	70.73	14.90	12.66	1.52	84.91
Local pounds	15-1-14	...	76.72	15.90	13.65	1.54	85.84
		16-2-14	73.25	16.00	12.97	1.75	81.08
		24-3-14	72.40	15.10	12.11	2.00	80.21
		24-4-14	71.59	14.85	12.19	1.67	82.09

An examination of these figures shows that the following deductions may be drawn:—(i) There was probably some reduction in the proportion of juice in the cane, due to loss of moisture during the period it was in clamp. Whether this was so during December is doubtful, but it certainly occurred during the three months from January to April. This is almost to be expected owing to a certain amount of drying; at the same time it is to be remembered that there is the error due to sampling, especially when, as in February, March and April, canes had to be drawn out of the heaps. Another error rests with the mill, which cannot be always tightened up equally at different times. Regarding the sucrose, glucose and purity, these did not change during December, the small variations which were found by analysis must be attributed to experimental error chiefly in sampling. The results of the December experiments are indeed remarkably satisfactory. During the much longer period January to April, the individual tests of the experiment marked "A" exhibit some variations no doubt due chiefly to sampling, but it is evident that except that the cane dried somewhat, this lot of cane suffered no

appreciable change. The lot of cane marked "B" probably suffered some small depreciation, but it was subject to slightly different circumstances. It has been mentioned that the local practice is to take up the cane with its surface roots intact. If, however, this mode of preserving cane for a factory were adopted, it was thought that this factor would add somewhat to the cost, costing rather more to lift from the ground and rather more to carry. Hence the lot of cane marked "B" was clamped without roots, but with leaves intact. This cane, as also all the other, remained practically perfectly sound, only the cut ends of the cane showing signs of rotting. This factor probably accounts for the somewhat greater depreciation of the juice, though it may be also partly due to error of sampling.

In any case these experiments show that sugarcane may be preserved in clamps over considerable periods practically intact.

Gur.—A number of samples of the locally made *gur* were analysed. These varied (with one exception) from 70—74 per cent. sucrose, and from 12-15 per cent. glucose.

Sugar-beet.—Two varieties of sugar-beet were sown, namely, Vilmorin and Klein Wanzleben. One plot of the latter was sown on September 20th, and plots of the former were sown on October 10th and 20th, November 10th and 20th and February 20th. Germination and subsequent growth were very good and uniform. Tests of these plots were made frequently, commencing naturally with the earliest sown. The samples consisted at first, in each case, of about 20 roots taken from uniformly distributed points over the plot, which enabled one to form an opinion on the progress of sugar formation, and so soon as the roots appeared to be well grown, the number of the roots was increased to about 100 per sample, taken similarly from uniformly distributed points. Not only do such samples yield accurate information as to the quality of the crop, but, together with a knowledge of the number of roots per plot, indirectly of its weight.

For example the following instances may be quoted to show how well duplicate samples agree :—

Year.	Number of roots.	Average weight per root, grms.	Estimated weight per acre, tons.	Sucrose in root per cent.
1913	100	756	14.68
	100	711	14.73
1914	97	612	14.9	11.9
	98	647	15.8	12.3

The following conclusions were drawn regarding the beet root crop :—

- (i) The average weight per root reached approximately 1 lb. at the end of six months from date of sowing if sown between September 20th and November 20th. Those sown on February 20th grew faster, and were fit to crush in June.
- (ii) The percentage of sugar was found to be between 12 and 13 in Klein Wanzleben and between 10 and 11 in the Vilmorin when the roots were still quite small.
- (iii) While the cold weather lasted the sucrose percentage remained rather low, but so soon as the hotter weather set in at the end of April there was a marked increase at least in all those sown on or before November 10th; thus we have :—

Sown.	Date of sample.	Sucrose per cent.
September 20th	April 21st	13.1
	May 7th	15.6
October 10th	April 22nd	11.2
	May 14th	15.3
October 20th	April 23rd	10.5
	May 15th	14.7

- (iv) The percentage of glucose was about .1 per cent. in each case.
- (v) The coefficient of purity was found throughout to vary from 80-90.
- (vi) The weight of roots was estimated to be about 20 tons per acre at the time of optimum quality.
- (vii) The roots sown February 20th were not tested later than May 31st when the sucrose had risen to 12.2 per cent., but they were perfectly sound and growing well at the end of June.

It is thus fairly evident that sugar-beets of good manufacturing quality can be grown so as to be ready by the middle of March, and by sowing on successive dates, the supply could be maintained until the end of June.

This investigation of the sugar capabilities of the Peshawar Valley has thus shown that—

- (i) sugarcane can be had in the field during December and January,
- (ii) that sugarcane may be preserved in a sound condition in clamps over the months February and March, and
- (iii) that a sugar-beet crop could be grown so as to supply a factory from the middle of March until the end of June. The factory would naturally have to be fitted to deal with both crops, but there should be no difficulty in arranging for this and the potential length of campaign, six or seven months, is unusually long.

Production of sugar-beet seeds.—A number of roots were transplanted for seed this year and some of these were tested at the time of transplanting, so that if seed is obtained, their progeny can be again tested and the process of selection of acclimatised plants commenced.

VII.—MILK.

Milk of Montgomery cattle.—Between December 1911 and June 1912 a series of tests of the quantity and quality of the milk of selected cows of the Montgomery herd at

Pusa was made in collaboration with my colleague Mr. A. C. Dobbs, then Imperial Agriculturist. The precautions which we employed in order to avoid experimental error as far as possible are dealt with in a succeeding paragraph.

Although the analytical part of the work was naturally completed day by day at the time, it was necessary, in order that the data obtained might have their full value, to examine them carefully and ascertain the probable errors mathematically. This portion of the work was done during the hill recess 1913, and explains why the subject was only briefly referred to in my last Annual Report.

Altogether three series of tests were made; with three cows in December and January; with twelve cows in April and May; and with ten cows in September to November. Most of these cows had calved recently and were in "full milk" or "fairly full milk."

Regarding the *yield* of milk, one half was obtained by hand milking (see succeeding paragraph) and from these data the total *production* of each cow was ascertained. This varied considerably, being as small as 8 lbs. in one case and as high as 18 lbs. and 21 lbs. respectively in two others. The majority produced from 10 to 14 lbs. per 24 hours. The *morning* and *evening* yields were found to be approximately equal in all cases; the periods between milking were 12 hours each. In respect of *fat* the percentage varied generally from 4 to 6, but was as low as 3.5 in one or two instances. The percentage of *solids-not-fat* varied from 8.2 to 9.0.

The *morning* and *evening* milk was not equally rich, the morning milk being systematically richer by about 1.0 per cent.; in some cases the difference was as small as .3 per cent., in others as high as 1.5 per cent.; the mean difference for the 25 cows was .91 per cent.

Tests of the yield and composition from *different parts of the udder* showed that:—

- (i) Usually the *yield* is approximately equal from the right and left side respectively, though there

were five cows which produced more milk from the one than from the other half udder.

(ii) In respect of *fat percentage*, with one exception, the milk was of equal richness from either half udder. The *quality* of the milk from the several *quarters* of the udder was tested in December and January for three cows, and here characteristic differences were met with, for in one case the milk was systematically richer from the fore, than from the hind-quarter, in another case it was systematically richer from the hind, than from the fore-quarter, whilst the third cow showed no such characteristic differences. Whilst the number of instances is so small that one cannot say that such instances are not exceptional, the tests were conducted over so long a period, upwards of two months, that the data are not to be ascribed to accidental error; they are real differences for the two cows, however exceptional such cows may be.

Errors involved in making milk tests.—When we decided to make a series of milk tests of the Montgomery cattle, it was apparent that an attempt should be made either to avoid several errors which are liable to occur and which very frequently minimise the value of such tests, or to estimate their magnitude. These may be briefly summarised.

(i) The number of cows should not be very small. Only three were included in the first period, but twelve and ten cows respectively were employed in two subsequent periods.

(ii) If the periods elapsing between milkings are unequal, it is known that this alone affects both the quantity and quality of the milk. As there was no difficulty at Pusa in making these periods equal, all the cows were milked at 12 hours' intervals, the variation in length of this period being not more than 5 minutes, which is a negligible quantity.

(iii) In India it is usually difficult to persuade a cow to yield milk to the hand without the calf sucking at the same time. At Pusa this was found to be regularly so. But obviously if the calf takes an unknown quantity of the milk, the total yield cannot be correctly ascertained; and without the adoption of special precautions this factor affects the percentage of fat also. The practice at Pusa with this herd is to allow the calf to take all the milk of one side of the udder whilst the other half is hand drawn, the idea being to ensure that the calves have a liberal allowance. It remained therefore to ascertain whether this practice is accompanied by any systematic errors, *e.g.*, is the one half udder as thoroughly stripped by hand as the other half is by the calf? The system which we adopted for these tests was to allow the calf to take the milk from one half udder, say the right, whilst the left half was hand milked, for two milkings; then for the following two milkings the calf was given the left half, whilst the right half udder was hand milked; and this sequence was followed day by day. During the first half of the period, *i.e.*, approximately for one month, the change from right to left side was made at the morning milking, whilst during the second half period, it was made at the evening milking. By the adoption of this system of milking it was evident that if the calf obtained more milk than the man (*i.e.*, if the hand milking were the less perfect) or if more milk were secreted during the night or day time, *systematic* differences of yield would be perceptible in the records which could be traced to one of these two causes. The data showed no such systematic differences and it became evident that the calf and man were equally efficient in stripping the udder. The source of error due to not being able to milk these cows entirely by hand, was thus avoided.

An examination of the data, both of yield and of percentage of fat, showed that the probable error of *individual* tests was unusually small. The probable error of yield for individual milkings was only $\pm .27$, and for percentage of fat it was only $\pm .29$, which are small when compared with

similar records which have been obtained elsewhere. The principal deductions depended on the arithmetical means of all the tests of any one period, and the probable error then fell to rather less than ± 1 both in the case of yield and percentage of fat. We were thus enabled to decide with great accuracy what differences were due to error of experiment and what were real differences in yield or quality.

Error due to milking in the ordinary way.—During a part (28 days) of the third period, September to November, the ten cows were hand milked as for profit, that is, the calf was allowed as little as possible, the object being to ascertain the magnitude of the errors which such a method would incur. The yields by hand were about 50 per cent. greater during this time, which was to be expected. It is also obvious that under such conditions the real quantity of milk secreted could not be ascertained. But in addition to this, the probable error of an individual milking rose from $\pm .26$ to $\pm .74$, that is, it became three times as great.

Detection of added water in milk.—During recent years the reliability of the freezing point of milk as a criterion of its freedom from added water has been recommended, chiefly by Brownlie Henderson in Queensland. It has been found by him and others that the freezing point of pure milk is so constant that a comparatively small addition of water, *e.g.*, 2 per cent., can be detected. At present the method is purely empirical and would only become dependable if a large number of tests showed what the variation of freezing point of pure milk is. To this end the freezing point of the milk of a number of individual cows and buffaloes at Pusa, at the Lyallpur Agricultural College and at the Military Dairy Farm, Peshawar, was determined, and it seems certain that even among individuals the variation in freezing point is only small. At Pusa it varied from -543° to $-577^{\circ}\text{C}.$, at Lyallpur from -527° to $-562^{\circ}\text{C}.$, and at Peshawar from -529° to $-564^{\circ}\text{C}.$. The variations between individuals are naturally greater than between samples of the mixed milks of a herd; thus

the freezing point of cow's milk at Pusa was $-555^{\circ}\text{C}.$, at Lyallpur -547° , at Peshawar -537° , and buffalo's milk at Peshawar -552° . The standard freezing point assumed by Winter is $-550^{\circ}\text{C}.$, and a freezing point $-537^{\circ}\text{C}.$ is equivalent to 2.36 per cent. of added water. Thus for mixed milks 5 per cent. of added water could be detected with certainty, whereas if dependence is placed on the percentage of solids-not-fat, there are cases where 10 per cent. could not be sworn to. Using Pusa cow's milk, to which known amounts of water were added, the freezing point indicated the following percentages of water :—

Indicated.	Actual.
5.6	5.6
10.9	10.0
19.0	20.0
21.3	25.0

VIII.—PROGRAMME OF WORK FOR 1914-15.

Major subjects:—

1. Examination of the sugarcane and sugar-beet crops at Peshawar and the storage of these crops in "clamps."
2. Experiments on possible improvements in the refining of saltpetre will be continued.
3. Records of the amount and nature of drainage water from fallow land and from land bearing crops are maintained.
4. An investigation of certain of the constituents of *Lathyrus sat.* is being conducted by the Supernumerary Agricultural Chemist.
5. The ratio of Argon to Oxygen and Argon to Nitrogen in soil gases under certain specified agricultural conditions is being determined.

Minor subjects:—

6. An attempt is being made to ascertain the nature of the hydration of clay in soils.

IX.—PUBLICATIONS.

The following have been issued :

1. The Yield and Composition of the Milk of the Montgomery herd at Pusa and Errors in Milk Tests. J. W. Leather and A. C. Dobbs. *Mem. Dept. of Agri. in India*, Chem. Ser., Vol. III, No. 6.
2. The System Potassium Nitrate, Sodium Chloride, Water. J. W. Leather and Jatindra Nath Mukerjee. *Mem. Dept. of Agri. in India*, Chem. Ser., Vol. III, No. 7.
3. The systems (A) Water, Magnesiuim Carbonate and Carbonic Acid, (B) Water, Calcium Carbonate, Magnesium Carbonate and Carbonic Acid. J. W. Leather and Jatindra Nath Sen. *Mem. Dept. of Agri. in India*, Chem. Ser., Vol. III, No. 8.

REPORT OF THE IMPERIAL ECONOMIC BOTANIST.

(A. HOWARD, C.I.E., M.A., A.R.C.S., F.L.S.)

I.—STAFF.

Charge.—I held charge of the section at Pusa during the year under review from October 18th, 1913, till June 30th, 1914. During the remainder of the period, I was on combined leave when the Second Assistant, Maulvi Abdur Rahman Khan, was in charge of current duties at Pusa. This assistant did good work during my absence and was rewarded by the grant of a charge allowance.

Staff.—The work of the staff continues to be satisfactory. In addition to the assistant mentioned above, the only case for individual mention is that of Lal Singh, who has been promoted to the post of Second Fieldman at Pusa. Fieldman Ram Prasad died during the year when the section lost the services of a loyal and hard-working man.

II.—WHEAT INVESTIGATIONS.

Distribution of Pusa Wheats in India.

In previous annual reports, a full account has been given of the preliminary work connected with the production and also with the trial of Pusa wheats in the various wheat-growing tracts of India. At the same time, reference has been made to the investigations on the influence of the environment on the milling and baking qualities of these wheats, which have been carried out in collaboration with Mr. Leake and with the invaluable help of Mr. A. E. Humphries. It is not proposed to refer now in detail to these preliminary matters which were fully described in the annual reports for 1911-12 and 1912-13.

The outstanding feature of the work of the last year has been the demonstration of the fact that one of the new wheats, No. 12, is the best for general cultivation both in the Gangetic plain and also on the black soils of Peninsular India. This wheat has also given satisfactory returns, both as regards yield and quality, in the *barani* tracts of the Punjab where it is now being grown by the cultivators. The behaviour of this variety is of the greatest importance in the work of improving the wheats of India. Judged by the returns obtained by the people themselves, not only in almost every District from Gurdaspur in the Punjab through the United Provinces to Bhagalpur in Bihar, but also on the black soils in Bundelkhand and in the Central Provinces, this wheat has invariably given the highest yield. At the same time, it has been demonstrated that its milling and baking qualities have been maintained unimpaired, both under *barani* conditions and also under canal and well irrigation. In addition to the satisfactory yield, the numerous trials of Pusa 12 by the cultivators in the United Provinces, during the last wheat season, have brought out the fact that it is able to maintain itself with far less water than late sorts like Muzaffarnagar, which need at least one more watering. Pusa 12 is a red chaffed wheat with good straw and its characteristic appearance in the field is of considerable advantage in the work of replacing the country wheats, which for the most part are shorter in the straw and have white chaff. The grain is white in colour and larger and more attractive than Muzaffarnagar. A single improved grade of white wheat can now be grown over a very large portion of the wheat-growing area of India. This will be an enormous advantage to the export trade and at the same time will be of great use from the point of view of the food of the people. For local consumption, Pusa 12 is worth at least two annas a maund more than ordinary Indian wheat.

Pusa 12, when placed on the Calcutta market for the first time this year, found a ready market at the mills and fetched four annas a maund above Bihar wheats on its

appearance alone. This fact is promising from the point of view of the first shipment of this wheat to Great Britain.

The distribution of Pusa 12 to cultivators is now being actively taken up by the Agricultural Departments of the United Provinces, the Punjab, Bihar and Central Provinces and all the available seed has been distributed. The supply, however, was far below the demand and, in particular, the indents from the United Provinces could only in part be met. Steps have been taken to remedy this and it is expected that the seed farms in Bihar and some of the indigo estates will be able to provide about 10,000 maunds of Pusa 12 in April 1915 to supplement the general seed supply of the Agricultural Department. On the indigo estates in Bihar, Pusa wheats are now almost exclusively grown and wheats like Muzaffarnagar have been given up.

A beginning has been made during the present year in the work of growing sufficient Pusa 12 at a few centres in the Central Circle of the United Provinces so that the surplus can be sent as a special shipment to England for the purpose of introducing this wheat on the Home markets. The co-operation of Mr. B. C. Burt, the Deputy Director of Agriculture, has been secured in this matter and the necessary financial assistance has been given by His Honour the Lieutenant-Governor of the United Provinces and by the Agricultural Adviser to the Government of India. By taking advantage of the development of the Co-operative movement in this Circle, it is hoped to replace systematically, from certain centres, the country wheats by Pusa 12 over large areas. The experiment is an interesting one, not only from the point of view of the trade in an improved product, but also as a means of discovering how far the Co-operative movement can be used in the distribution of an improved variety in a systematic way.

Another aspect of the success of Pusa 12 over so large a portion of the wheat-growing area of India remains to be considered. It is sometimes stated that the agricultural conditions vary so much in India from province to province and also in different parts of the same province, that

the work of improving any widely cultivated crop can only be done locally and at a number of stations. In reality this idea is not supported by the facts. It is true of course that the conditions under which wheat is grown in India vary widely, and that a knowledge of these conditions is essential in the work of improving the crop. It is also true that a single area of fifty acres in the Gangetic alluvium, if skilfully selected, exhibits an exceedingly wide range of soil conditions, which, from the point of view of the requirements of the wheat crop, vary almost as much as any two of the wheat-growing provinces of India. By taking advantage of this circumstance, it is possible to make a single wheat-breeding station serve for almost the whole of India.

Wheat Breeding.

The fourth generation of the crosses between Indian and English wheats, referred to in the previous report, have been worked through during the year. A large range of individuals has been selected for further growth, all of which are characterised by strong straw, rust resistance and attractive looking grain. The range in time of ripening of these plants is very great. Some are earlier than Pusa 4 while among those with enormous tillering power are numerous individuals which will probably ripen too late for any of the wheat tracts of India except possibly the Quetta valley. This group of wheats is by far the most promising material obtained at Pusa. Some types will probably be fixed in 1915, after which they will be tried in the various wheat-growing tracts.

III. - OTHER INVESTIGATIONS.

Tobacco.—Progress continues to be made in the tobacco investigations at Pusa.

Further results have been obtained with the cigarette tobacco known as Type 2S. A good many of the indigo estates in Bihar are now growing this tobacco for the Indian Leaf Tobacco Development Company at Dalsing Serai and.

in April last, an increased quantity of self-fertilized seed was distributed. The yield of this tobacco under estate conditions is very satisfactory and it is also being taken up by the cultivators for the local trade. On a few estates, Type 28 is being cured on racks, the price obtained for the first quality leaf being Rs. 25 per maund. Arrangements have been made to grow at Pusa the seed of this tobacco required by the planters and others so that this variety can be maintained true to type and natural crossing prevented.

The importance of improved methods of growing the seedlings of this crop was referred to in the last report. By partially sterilizing the seed beds, the seedlings grow faster and stronger and are ready for transplanting about a week or so earlier than when grown in the ordinary way. It is a great advantage in Bihar to be able to rely on an abundant supply of strong seedlings at the proper time so that even fields can be established on the *hathia* rains. Work is in progress at Pusa with the object of devising the most economic method of adapting the results obtained to estate conditions.

Interesting results were obtained during the year on green manuring for tobacco with *sanai* (*Crotalaria juncea*, L.). These results supplement those already published in the *Agricultural Journal of India* (Vol. VII, 1912). It was found then that if the interval of time between ploughing in the green crop and transplanting the tobacco exceeded two months, the effect of the green crop diminished and finally disappeared altogether. During the past year, the effect of diminishing the time between ploughing in the *sanai* and planting the tobacco was tried. It was found that any period less than two months was too short for the decay of the green manure and when the period was less than one month the crop obtained was very poor. Across the plots in which the *sanai* had less than two months to decay, a broad strip was subsoiled some time after the green crop was put under. The result was a great improvement in the vigour of the tobacco crop and the subsoiled strip stood out markedly from the rest. It is prob-

able that these latter results can be explained by the work of Kidd (*Proc. Roy. Soc.*, B, Vol. 87, 1914) who has shown that the decay of green manure produces so much carbon dioxide in the soil as to inhibit the germination of seeds. Until a certain stage is reached in the decay of a crop like *sanai*, it is quite possible that want of oxygen and excess of carbon dioxide would be limiting factors to a rapidly growing crop like tobacco. That a poor germination is obtained if seeds are sown soon after a green crop of *sanai* is ploughed in, was observed twice during the past year at Pusa, once in the case of Java indigo and once in the case of tobacco sown in a nursery which had been recently green manured with *sanai*. The absence of any marked crop increase on the heavy lands in Bihar, following a dressing of *seeth*, and also the poor crops obtained on such lands after *sanai* ploughed in (especially in wet years or when the soil is waterlogged by flooding) are probably also connected with oxygen supply. Kidd's researches are likely to prove of considerable interest to India.

A paper is in preparation, by the Personal Assistant, on the inheritance of characters in *Nicotiana rustica*, L., the observations on which were brought to a conclusion during the year.

Gram.—The selection work on this crop was continued and three of the most promising types, including the high yielding white gram which was valued so highly at Bombay in 1912, have been distributed for trial on estates in Bihar and also in other tracts of India. A certain amount of natural crossing takes place in this crop, the extent of which under Bihar conditions is now being investigated.

Fibres.—The work on the inheritance of characters in *Hibiscus Sabdariffa* was continued, but it was not found possible to complete this investigation during the year. The work is being continued.

The behaviour of some of the cultures of *sanai* (*Crotalaria juncea*) at Pusa indicated that extensive natural crossing takes place in this crop when two or more varieties are grown next to next. The pollination mechanism in the

flower has been worked out and the functions of the long and short stamens elucidated. Very little selfing under nets takes place in this crop, the flowers only setting seed normally after being visited by bees. These facts render variety trials in this crop exceedingly difficult.

Methods of pollination.—It is hoped during the next few months to bring out a second memoir dealing with natural cross fertilization and to include in it the observations of this subject made at Pusa since the first memoir was published in 1910.

Drainage.—The great importance of a system of surface drainage in Bihar, which allows each field to deal with its own rainfall only and also prevents the loss of fine soil by surface wash, has been observed for some years at Pusa. The subject has been brought to the notice of the planting community in Bihar in a paper read at the meeting of the Bihar Planters' Association in January last. The Pusa method has been taken up with success on several estates and a great deal of attention is now being devoted to the subject. On the Dholi Estate, the lands are being divided up into drained areas about five acres in extent so as to admit of the use of reapers and other labour saving devices in the cultivation of wheat for seed purposes. Mr. Danby, in a letter dated January 3rd, 1914, gives his opinion on this system of drainage as follows:—

“ During the past year I have applied the system of surface drainage to some 40 bighas and I intend to extend it to the whole of my factory *zerats* here and at the outworks. The lands which I drained in this way this year were formerly, in a wet year, more or less waterlogged the whole of the rains owing to the water from the higher lands draining into them. This year I was able to cultivate and keep them clean all through the rains and even after the late rains which we had this year I was able to sow wheat in them before the end of October.”

A note on the subject of drainage and soil demudation by rain wash was submitted to the Board of Agriculture at

Coimbatore. This has since been published in the *Quarterly Journal of the Indian Tea Association*.

Indigo.—The present position of the indigo investigations has been dealt with, in detail, in a report to the Bihar Planters' Association published in January last.

The area under Java indigo in Bihar has fallen since 1909-10 from 70,000 to about 15,000 bighas in 1913. During this period, the area under Sumatrana indigo has remained constant at about 45,000 bighas. The decline in the area under Java indigo has been a serious blow to the planting community in Bihar. As is well known, this species is much richer in indican than Sumatrana which latter was exclusively grown in Bihar till the introduction of Java indigo in 1898. The rapid increase in the area under the Java plant gave rise to the hope that the decline of the natural indigo industry would at least be arrested. Difficulties, however, arose after the cycle of dry seasons came to an end in 1908. The crop showed signs of tailing off in vigour, the yield of leaf became less and difficulties in growing the crop for seed were of frequent occurrence. The poor seed sown gave rise to still more weakly crops with the result that the area declined eighty per cent. in four years. The cause of the trouble is regarded locally as a disease to which the name of 'wilt' has been given. The nature of the disease has been investigated both by the Sirsiah Experiment Station and also by the Mycological, Entomological and Bacteriological Sections of the Pusa Research Institute. In all cases the results obtained were negative. The matter was also referred to the Botanical Section at Pusa. It was found that the wilting of Java indigo, which takes place after the first cut in July, was due to the loss of the active root system of the plant, resulting from a long continued wet condition of the soil. Similar wilting is common in Bihar in crops like *patwa* (*Hibiscus cannabinus*) and *sarai* (*Cotalaria juncea*) when sown at the beginning of the monsoon for seed purposes. All these deep-rooted crops are sensitive to a constantly wet

soil and lose their active root system if this condition persists for too long a period.

In searching for some practical remedy for this trouble, two lines of attack suggested themselves. In the first place, improvements in surface drainage and aeration of the soil might be expected to prolong the life of the plant. Secondly, sowing the crop specially for seed towards the end of the monsoon, so that the developing root system would follow the fall of the subsoil water, was a second possibility in case improved drainage and cultivation failed to avert the trouble in the case of indigo grown in the ordinary way. Both these methods were tried simultaneously.

Among the various methods of surface drainage and interculture, tried during the monsoon on indigo cut for leaf in the ordinary way, no practicable remedy for the trouble was discovered. The waterlogging, which takes place in the fine Bihar alluvium and which leads to the destruction of the young roots of the indigo, cannot be entirely prevented by ordinary surface drainage and cultivation. The plants will not tolerate the constantly moist condition of the soil for the whole of the monsoon period.

In the case of August sown indigo, very different results were obtained. The plants grew rapidly, escaped wilt altogether and gave rise to a fine crop of healthy seed the following March. After reaping the seed, the plants were cut back and then gave a good crop of leaf in the ordinary way the following rains. Similar results were obtained on a large scale on the Dholi estate. The Pusa results showed that, for seed purposes, Java indigo should be sown thickly, in lines about two feet apart, early in August on high, well drained land in good condition. In this way the plants escape the disease. They grow to a large size by the end of October and so carry a heavy crop of seed the following cold weather. Thus one of the main obstacles to the cultivation of Java indigo in Bihar has been removed and the planting community are now in a position to grow their own seed without any great outlay. After gathering the

seed, the indigo can be cut back and good crops of leaf taken the following monsoon.

Attention has also been paid to the method of pollination in Java indigo, from the point of view both of seed growing and of improving the plant in indican production. Pollination by bees is the rule and very few seeds are produced by covered plants. As would be expected from the method of pollination, the progeny of single plants showed that natural crossing is common. These facts indicate that ordinary single plant selection methods in Java indigo are not likely to yield results at all commensurate with the work which this method would involve. Some system of mass selection, in which undesirable forms are eliminated prior to flowering, seems much more likely to lead to improvement. Advantage will have to be taken of those individuals in the mixed crop which grow rapidly and strongly and which by their habit of growth and amount of leaf surface are likely to give the highest yields of green leaf. These will have to be grown separately, away from other indigo, and a process of rogueing carried out before flowering time so that all undesirable types are weeded out and not allowed to cross with the rest. The fact that bees are necessary for the pollination of Java indigo indicates that for seed purposes the plants should be properly spaced and not grown too close together. Copious setting is obtained if the crop is grown in lines about two feet apart. Cultivated in this way, Java indigo branches freely from the ground and there is ample room for the bees.

During the progress of the indigo investigations it became evident that one important method of improvement had been, to a large extent, neglected. In the past, it has been tacitly assumed that the methods of cultivation in vogue in Bihar are more or less perfect and that any line of advance must necessarily begin in the laboratory. The results obtained at Pusa have shown that a considerable degree of improvement is easily possible in the actual grow-

ing of the crop. Further, these improvements are well within the means of an ordinary indigo estate.

After the removal of the cover crop, it is the usual practice in Bihar to weed the young indigo crop by hand. This process is tedious and expensive and the work is not always well done. By the use of lever harrows in the early stages, and by the use of spring tine cultivators later on, a great deal of hand weeding can be avoided and at the same time the young crop is greatly improved by the cultivation. These lever harrows have been tried extensively on the Dholi Estate for two seasons and Mr. Danby reports as follows on the trials (Letter, dated January 3rd, 1914) :--

" I meant to have written before about the lever harrows. I had six of these harrows in use last year and I have ordered six more from Messrs. Massey Harris.

" I harrowed practically the whole of my Java crop in February and March last after cutting the cover crop—wheat and *sursoo*. The crop was greatly improved by the harrowing, besides which the wheat stubble and weeds were to a large extent removed. I estimate that the amount saved in weeding alone in one year was more than the cost of the harrows."

Some consideration has been given at Pusa to the discovery of some practicable method of reducing the amount of wilt among Java indigo when grown for leaf. Very promising results were obtained during 1913. As is well known, the universal method of growing Java indigo in Bihar is to sow it either broadcast or by drills in lines close together. The result, in both cases, is a dense crop of unbranched plants among which leaf-fall rapidly takes place due to the crowding of the plants, thus leading to a great loss of indigo. Further, interculture to keep down weeds is impossible after the first cut. When the crop is reaped, the indigo is cut down completely and the plant has to produce new shoots during the monsoon at a time when its roots are in very moist soil. Few plants will survive uninjured such treatment during a heavy monsoon. When an indigo plant is suddenly cut down, the passage of

water and food materials from the roots goes on for a time and the stumps bleed. There are no leaves to carry on the transpiration current and the result is that the normal physiological processes in the plant are greatly upset. It is not surprising therefore that the new growth is formed so slowly and that it is often unhealthy. Many plants, such as peaches and flowering creepers like *Ipomoea*, usually die outright when cut down to the ground during the rains and hardly ever recover. It was decided in 1913 to try the effect of pruning the crop in July at the time of the first cut and to compare the behaviour of plants treated in this way with those cut down completely. The crop was grown in lines, two feet apart, to allow of branching. One half of the plot was cut down in the ordinary way, the rest pruned so that one branch was left at cutting time. The result was that the pruned plants began to shoot earlier than those which had been cut down and moreover escaped wilt to a much greater extent. The total yield from the pruned plot was about thirty per cent. greater than that of the area cut down completely. Work on this subject is being continued with the object of finding the most economic method of growing the crop so that it can be pruned at the first cut instead of being cut down completely.

IV.—THE DEVELOPMENT OF THE FRUIT INDUSTRY OF BALECHISTAN.

In the previous annual report, a complete account was given of the work at Quetta relating to the development of the fruit industry in Baluchistan. A brief reference to the progress made during the past year will suffice to bring this subject up to date.

Fruit and Agricultural Experiment Station.

Considerable progress has been made in the preliminary work relating to the laying out and equipment of the new Experiment Station at Quetta. The land has been laid out in large terraces with a suitable slope for irrigation in two directions. Water can now be brought on to about three-

quarters of the terraces by means of two bricked channels so that the loss of water during irrigation has been reduced to a minimum. The rest of the area is commanded by earth channels only. A pucca road now runs through the area, the farm buildings, which include quarters for the overseers and workmen, have been erected and the work connected with the artesian bores has been completed. One of these bores has been fitted with an oil engine and a centrifugal pump and has been very thoroughly tested by pumping on it for eight hours a day for a month. By this means the flow was increased from one to about three thousand gallons an hour without affecting the normal flow. A certain supply of irrigation water is now assured whatever may be the future of the large *Sirkhi karez* of which two *shabanus* of water belong to the Experiment Station.

The method of ring budding seedlings in May and June has proved a great success under Quetta conditions and during the past year about 2,000 budded trees have been distributed. All the young trees are pruned in the nursery during the first year's growth and properly trained before issue to the public. In order to check waste of stock, all the trees, except those for Government use, were sold at the rate of two to the rupee. At the end of the present year it is expected that from six to eight thousand trees will be ready for distribution.

Experience during the past year has confirmed the opinion given in the last report that by suitable methods of moisture conservation a great saving of irrigation water is possible in Baluchistan. Further saving of water is possible by a proper grading of the surface and by bricking the main distributaries. In the case of wheat, a yield of 18 maunds 30 seers per acre was obtained on an area of about three acres with one irrigation only. This was applied before sowing in October so as to ensure a good germination. Afterwards the soil moisture was conserved by means of a surface mulch produced by lever harrows. The ordinary yield of irrigated wheat near Quetta is not much over twenty maunds per acre and the usual number of waterings

is six to eight. The great saving of water possible by the use of a surface mulch in the case of a wheat crop is therefore obvious.

The growth of Persian clover (*shaftful*) as a green manure at Quetta continues to give excellent results. When sown in August, this crop gives three cuts of green fodder weighing about 60,000 lbs. per acre before the end of the following May. In addition, the last cut is either ploughed in as green manure or a crop of seed is raised. A marked improvement in the water holding capacity and tilth of the soil follows this treatment. A small amount of seed was distributed during the year and arrangements are being made to raise a large quantity this summer.

The investigations, referred to in the previous report, on the yellowing of peach trees have resulted in the discovery of the cause and of an easy method of prevention. In the vegetable gardens in the Civil Station of Quetta the peach trees have, as a rule, very yellow foliage, often accompanied by excessive gumming. Such trees die very quickly and do not bear a large crop once the unhealthy symptoms are well marked. The early symptoms appear to be identical with the disease in the Eastern United States known as "Peach yellows." The later symptoms of the disease, namely, premature reddening and ripening of the fruit, are however not developed. The yellow condition is not propagated by buds taken from affected trees and thus the disease is not the "Peach yellows" of the United States. Applications of soluble nitrogenous manures, such as nitrate of soda or sulphate of ammonia, gave negative results, so that want of available nitrogen is not connected with the trouble. It was found that if *shaftul* is grown round the affected trees the disease slowly disappears and the trees produce healthy growth. This result suggested that the yellowing of the foliage is due to want of air in the subsoil which follows the system of surface irrigation without any subsequent cultivation now in use at Quetta. During the present year this opinion has been confirmed. Some of the peach trees at the Fruit Experiment Station were over-irri-

gated by surface flooding during March and April last and by the beginning of May the new foliage showed the characteristic yellow tinge. Irrigation was stopped and the soil round the trees was well cultivated right down to the roots. In less than a fortnight the yellowness disappeared and the trees now show the characteristic shiny green foliage of vigorous growth. By growing the *shaftal* in beds between the lines of peach trees and by keeping the strip of soil, in which the trees occur, well cultivated the relations between air and moisture in the soil most suitable for the peach can be maintained. After the buds open in March the trees should only occasionally be watered directly as the roots get sufficient water when the beds of *shaftal* are irrigated.

The sale of improved fruit boxes to the public and the trade was continued during the year. These are now in general use at Quetta and during the present summer it is hoped to complete the experimental work on this subject and introduce several more improved packages.

During my absence on leave in 1913, Colonel Duke, I.M.S., Residency Surgeon and Chief Administrative Medical Officer in Baluchistan, kindly agreed to inspect the work from time to time and to give any necessary advice to the Assistant in Charge. This arrangement proved most useful.

V.—PROGRAMME AND PUBLICATIONS.

Programme of work for 1914-15.

Plant breeding and plant improvement.—Work will be continued on the following crops on the lines indicated in the annual reports and in the publications of the section—wheat, tobacco, gram, fibre plants, indigo, oil seeds and fruit.

Publications.

Very little progress was made during the year in the publication of results. This part of the work is now in arrears, but a special effort is being made this summer to bring the publication of results up to date.

The following papers were published during the year :—

1. The Improvement of Indigo in Bihar (with G. L. C. Howard). Published by the Bihar Planters' Association.
2. Soil Denudation by Rainfall and Drainage. The Conservation of Soil Moisture. *Quarterly Journal, Indian Tea Association*, Part I, 1914.
3. The Seed Supply of the New Pusa Wheats (with G. L. C. Howard). Reprinted in the *Agricultural Journal of India*, Vol. IX, Part III, 1914.
4. Notes on Drainage and Green Manuring (with G. L. C. Howard). *Agricultural Journal of India*, Vol. IX, Part II, 1914.

REPORT OF THE IMPERIAL MYCOLOGIST.

(F. J. F. SHAW, B.Sc., A.R.C.S., F.L.S.)

I.—CHARGE AND ESTABLISHMENT.

Dr. Butler held charge of the section until 28th March 1914, when he proceeded on privilege leave and furlough; since this date I have been in charge of the section. I was absent on duty in Madras up to 31st October 1913, when Mr. McRae, Government Mycologist, Coimbatore, returned from leave.

S. Pasupati Iyer, second clerk, resigned to take up the Sericultural course on 22nd November 1913, and Nripendra Chandra Sen filled the vacancy thus caused until 26th March 1914, when Md. Taslim was appointed. All the staff have worked well.

II.—TRAINING.

Mr. A. C. Tunstall, Mycologist to the Indian Tea Association, worked in the laboratory as a visitor for about a week in September and Mr. G. H. Alington, I.F.S., Assistant to Forest Botanist, was deputed to study some tree diseases in January. Babu B. L. Gupta, B.Sc., Professor of Biology in the Reid Christian College, Lucknow, attended the laboratory during May and June and received a course of lectures and practical work on the morphology of the fungi.

III.—DISEASES OF PLANTS.

The investigation of the diseases of crops, the collection and identification of Indian fungi, and the giving of advice to cultivators and officers of the Department formed the principal work of the section.

(1) *Paddy Disease*.—The most serious disease of paddy is that which is known in Eastern Bengal as "ufra." An account of this trouble has been published in

Bulletin No. 34 of the Department while popular descriptions have appeared in the *Agricultural Journal of India* and in a Bengali leaflet. It has been established that the organism responsible for the damage is a form of eelworm (*T. angustus*) belonging to the genus *Tylenchus*, of which several species are known to cause serious diseases of cereals. Inoculations with material which, so far as could be determined, contained no other constant organism but the worm, have been successful in producing typical "ufra" in localities where the disease was quite unknown. The disease commences its ravages in July and culminates about September-October when large numbers of motile worms are present. After December they remain immotile and dormant in the dry grains and probably recommence activity only with the flooding of the fields after sowing; in this connection experiments have shown that *T. angustus* can withstand desiccation for even 15 months. It is a curious fact that transplanted paddy appears to be comparatively immune to natural attack. During the present year efforts have been made to map out the extent of the infected area and an experiment is in progress at Comilla to test remedial measures. It is probable that burning the stubble on the soil after winter harvest will be found to be the most efficient means of combating this disease. The infected area in Eastern Bengal appears to stretch from the Madhupur jungle north of Dacca to the river Mahari in Chittagong District. Westward the disease is bounded by the Padma but the eastern limit is uncertain, the infected area almost certainly reaches to the Meghna and further search is needed in the direction of Sylhet. In Tippera the northern limit of infection is near Akhaura on the Assam-Bengal Railway and the disease is particularly virulent in this district at Narjanpur, Comilla and Chandpur, at Begumganj and Chawmuhani in Noakhali District, and also at Fenni in Chittagong District. The most important fact in the distribution of this disease is that it has recently been identified with the "sanhra" condition of paddy in the Khunti Sub-Division near

Ranchi; further investigations will be carried out in this area.

The losses caused by "ufra" are very heavy. In Begumganj thana in 1910 the loss was estimated at 200,000 maunds of grain and in Chaumuhani in 1911 nearly half the winter crop was lost. The supreme importance of paddy as a food crop in Bengal and the virulence of this disease will make it the major work of this section for some time to come.

An account of *Sclerotium Oryzae* Catt. was published as a memoir of the Department. This fungus has been found attacking rice in Burma, in Madras, and also in Bihar and Orissa, in which latter province it has been collected at Cuttack, at Pusa and near Ranchi. Paddy infected by this parasite usually shows excessive tillering and lightness in the grain, in fact there is frequently nothing within the glumes. In culture the morphology of the fungus proved more or less dependent upon the nature of the nutrient medium. The observations of Cattaneo, who regarded the sclerotia as spore containing organs, were not confirmed in the present memoir.

Brief accounts of Rice Bunt (*Tilletia horrida* Tak.) and False smut [*Ustilaginoidea virens* (Cke.) Tak.] were published in *Bulletin* No. 34. The former has been the cause of complaints from Germany, its spores having been found in rice imported from Burma and Siam. Effective remedies for this type of disease are known, should the trouble become severe.

(2) *Sugarcane disease*.—Complete accounts of the principal diseases of this crop were published during the year as memoirs of the Department.

"Red rot" has been the subject of previous publications of this section. In the most recent communication the authors have worked out the mode of air-borne infection in the field, a point which had long been obscure. It was found that infection took place chiefly at the adventitious root eyes, although penetration was also easy at the shoot

buds. The chief source of infection was the form of *Colletotrichum falcatum* which occurs on the mid ribs of leaves. The process of sett selection, described in previous publications, offers the best method of combating this disease. In districts where the local cane is badly diseased a fresh healthy type of cane should be imported and setts inspected carefully each year before planting. Fortunately in India we have a large range of these canes of hardy habit and great tillering power, which are relatively immune to red rot and it has been found possible by hybridisation to combine the characters of such canes with those of the thicker, heavier yielding varieties of other countries. The introduction of new and immune varieties of cane has been very successful in Bombay Presidency. The Imperial Mycologist visited Surat in October last and concluded that while the present state of the cane was good an outbreak of disease must be expected unless there is a marked improvement in local cultivation. At present the canes are grown in low lands and are practically water-logged. The adoption of the Godavari trench system or the nursery system of cultivation common in Ganjam is recommended.

The wilt disease of sugarcane was found to be due to the attack of *Cephalosporium Sacchari* Butl., a hitherto undescribed species. This disease strongly resembles "red rot," but in the case of infection by air-borne spores the plant was found to be far more susceptible to infection at stem wounds than in the previous case. The disease has been found at Surat, Poona, Samalkota and throughout North-eastern India. The control of the trouble should be on the same lines as in true red rot. As, however, wound infection is more common, the importance of removing diseased clumps before they have time to rot and set free spores is much greater. It is probable that this disease is incapable of doing permanent damage so long as the measures advocated against red rot, which are essential to the successful growing of thick cane in Northern India, are carried out.

"Collar rot" of sugarcane is due to the attack of *Hendersonina Sacchari* Butl., a hitherto undescribed genus. The outward symptoms are a withering of the top and a black rot of the roots; the lower nodes show a red discoloration in the pith. The roots and the base of the stem are full of the hyphae of the fungus from which cultures are easily obtained. Both in cultures and on diseased canes a pycnidial stage was observed; the pycnidia are peculiar in containing two types of spores in the same loculus. Inoculations with pure cultures of the fungus were carried out at Samalkota and were successful in producing the disease. This disease occurs at Samalkota and at Jorhat; the extent of the damage caused by it is unknown.

Helminthosporiose of sugarcane is due to the well known genus *Helminthosporium*, of which *H. Sacchari* Butl. is a new species. This fungus is common on the leaves of sugarcane in Pusa where it produces small red discolorations. Inoculations with pure cultures were successful. The damage done by this disease is at present negligible.

Smut of sugarcane (*Ustilago Sacchari*) has been under observation in the Central Provinces and culture work with this fungus is now in progress at Pusa. "Sereh" of sugarcane was reported at Jorhat and Coimbatore during the year. The Imperial Mycologist visited Coimbatore in October last and satisfied himself that "sereh" disease was not present.

(3) *Palm diseases*.—During the year an outbreak of bud rot took place among the coconut palms of Malabar. The disease was investigated by the Supernumerary Mycologist, who was at that time officiating as Government Mycologist, Madras, and proved to be due to *Pythium palmivorum* Butl., the cause of the palmyra palm disease in the Godavari district. The fungus was studied in pure culture for the first time and inoculations were successfully carried out. It was found that the fungus was particularly active in producing rows of spots on the young leaves

of coconut palms. From such infections the fungus reaches the central bud by means of motile zoospores being washed down the leaves. Once the soft white leaf bases are reached a virulent rot takes place leading to the death of the tree. As the result of numerous observations on the discharge of zoospores it was concluded that the fungus probably belongs to the genus *Phytophthora* and not to *Pythium*.

Active measures, on the lines of those in operation in the Godavari, have been taken against the disease by the Government of Madras. A popular account of this trouble has been published in the *Agricultural Journal of India* and the more scientific results have appeared in the *Annales Mycologici*.

A "collar rot" of areca palms has been identified in Sylhet and Khulna and is probably due to *Fomes lucidus* (Leys) Fr. This fungus also occurs on *Guazoma* and pure cultures have been obtained from this source by Mr. Hafiz Khan. Inoculations have shown that the fungus is a true parasite on *Guazoma* and work is being continued on the areca palm.

(4) *Rhizoctonia*.—In January last there was a bad outbreak of disease on Pusa Farm due to this fungus. The crop affected was chiefly mustard, but the parasite was almost omnivorous. The fungus was *Rhizoctonia Napi* West—a species not previously observed in India. It is under observation in pure culture; it appears to be incapable of growth at the temperature of the hot weather and rains in Pusa.

A rot of stored potatoes at Sabour and Bankipore was also due to *Rhizoctonia*. The species *R. Solani* Kühn was common and in one case a very bad rot was identified as due to *R. destruens* Tass. The latter fungus was also a virulent parasite on *Delphinium* at the Alipore Horticultural Gardens, Calcutta; in fact it was its occurrence on this plant which enabled it to be identified on the potato.

At the beginning of the year numerous specimens of diseased poppy plants were received from the officials of the

Opium Department in the United Provinces. The specimens were infected sometimes by *Rhizoctonia* and more rarely by *Peronospora arborescens* (Berk.) de Bary. I visited Basti in March and concluded that the diseased condition of the poppy crop was due rather to the practice of keeping certain fields under poppy year after year than to any parasitic infection. The fungi found on the plants are a symptom rather than a cause of the condition of the crop. Investigation will be continued next season.

(5) *Cotton and Sesamum wilts*.—An attempt was made to define the southern limits of extension of cotton wilt, which the previous year had been traced from the Central Provinces to Belgaum. It was found to be present very sporadically in Bellary District, presumably as an extension from the Dharwar side, but a careful search at Guntakal in Anantapur District and Nandyal in Kurnool District failed to show any trace of the disease. As no reports of its occurrence elsewhere in Madras have been received, it may be assumed that only the extreme north-west of the Presidency has been reached. On the other side typical cases have been received from the Nadiad Farm near Ahmedabad though the disease appears to be little prevalent in Gujarat. Cotton wilt is, therefore, present in the western part of the Central Provinces, practically the whole of Bombay, exclusive of Sind, and the north-west corner of Madras. It is severe in parts of the Berars and threatening in parts of Khandesh, but elsewhere, at present, does little damage. The cause was definitely established during the year to be a species of *Fusarium*, successful inoculations with pure cultures of the fungus having been secured. Through the kindness of the United States Department of Agriculture an opportunity was obtained of comparing the Indian cotton wilt fungus with *Fusarium vasinfectum* Atk., the organism which is the cause of cotton wilt in America. There are considerable differences between the two parasites and it is probable that the Indian fungus is a distinct species. It is also probable, though accurate information on this point is

not yet available, that the Indian disease is decidedly less virulent than that in the United States. India is fortunate too in possessing a race of cotton, "buri," which is absolutely immune to the disease. Arrangements have been made, through Mr. Clouston, Deputy Director of Agriculture, Central Provinces (to whom the discovery of this property of "buri" cotton is due), to supply seed of this variety for trial in the United States in wilt infected tracts, and in return we are to receive American wilt-resisting varieties for trial in India. There is no other known method of fighting *Fusarium* wilts but by the growth of immune or resistant varieties.

Sesamum wilt has also been proved to be due to a *Fusarium*, and cross inoculations have confirmed what was already probable from morphological study, that the cotton and sesamum diseases are distinct and are due to different species of *Fusarium*. It is, in artificial inoculations, a much more virulent disease than the cotton wilt, proving fatal in every case tried—several hundreds. No resistant variety is known, but the cold weather (*rabi*) crop is less subject to the disease than the monsoon (*kharif*) varieties. Further work on these diseases will be resumed when opportunity arises.

(6) *Phytophthora* investigations.—The potato blight due to *Ph. infestans* (Mont.) de Bary, was investigated by Mr. J. F. Dastur, First Assistant. It was discovered that the fungus does not survive in the heat of the plains of India and is not therefore likely to become a serious pest, except possibly in the hills. A species of *Phytophthora* has also been discovered attacking *Lilium* and *Petunia*; it is a variety of the *Ph. parasitica* on castor which has been the subject of a recent memoir. The slight variation in measurements and a few differences in the inoculation experiments may be accounted for by the influence of the host plant.

(7) *Anthracnose*.—This disease has been investigated upon the betel vine, plantain, chili and papaya. In the case of the betel vine the perfect stage of the species of *Colletotrichum* has been discovered to be an Ascomycetes

and the *Colletotrichum* and *Glaeosporium* upon chilli have been proved to be one and the same fungus. The most important feature of the work on this crop is that the disease appears to be transmitted through the seeds. Various methods of seed treatment will be tried during the current year and experiments will also be conducted in the spraying of plantains against anthracnose.

(8) *Groundnut leaf disease*.—The relation between the incidence of the *tikka* disease of groundnut and the amount of cultivation and export of that crop was the subject of an inquiry during the year under review. Between 1894 and 1902 the export of groundnuts fell from 78,488 tons to 2,890 and the trade became practically extinct. The fall in the exports was due not to any deterioration in the quality of the produce, but to a marked decrease in the yield per acre, which appeared to be the result of a fungal disease, known locally as *tikka*. Treatment with fungicides had no effect in stopping the disease and, in 1902, the Bombay Department of Agriculture commenced the introduction of exotic varieties. These varieties were also attacked by *tikka*, but some, which ripened early, did not have their yield appreciably affected. Two varieties from Japan were especially useful in forming their nuts before the disease was sufficiently established on them to damage the produce. As a result of this, the exotic varieties, introduced by the Bombay Department of Agriculture, have now replaced the indigenous in all districts except the Poona district. Moreover by 1912 the *tikka* disease had decreased to such an extent that, in the whole Bombay Presidency, diseased specimens could only be obtained on the Manjri Farm. Coincident with the introduction of exotic varieties and the decrease in the amount of *tikka* disease the exports began to rise. In 1902 they were 2,890 tons, in 1906 they were 6,527 tons, in 1909, 23,934 tons, and in 1912, 48,801 tons. This is probably one of the most marked cases on record where a crop disease has been checked and a trade rejuvenated by the introduction and acclimatisation of new varieties.

(9) *Other plant diseases*.—A trial was made of the hot water treatment, which is so useful in the case of oat smut, against smut of bajra; the treatment proved useless. The treatment of oat smut by formaline steeping was successfully demonstrated on several estates in Bihar. Investigations into phanerogamic parasites and in particular the influence of chilli saltpetre on *tokra* of tobacco were resumed.

IV.—SYSTEMATIC WORK.

There were 505 additions to the herbarium during the year under review. Of these new additions we are indebted to the Bureau of Science, Manilla, and to mycologists in Berlin for 269 species. Named collections of Indian Fungi were sent in exchange. Collections of fungi for naming were received from, and duplicates were issued, if required, to the Mycological Officers of Provincial Departments of Agriculture and the Curator, Royal Botanic Gardens, Calcutta.

The systematic study of the large collections of *Deuteromycetes (fungi imperfecti)* in the Herbarium was taken up and material obtained for a fifth part of the *Fungi Indiae Orientalis*; the series is being published in collaboration with H. & P. Sydow, Berlin.* At least one other part will be required to finish this large group.

A short paper was published describing the complete stages of the rusts of sugarcane, figs and *Oldenandia*.

V.—MISCELLANEOUS.

The Imperial Mycologist attended the Board of Agriculture in December and the centenary celebrations of the Indian Museum in January. Assistance was given to the Imperial Bacteriologist in the identification of a fungus isolated from bursati tumours and in an inquiry into the relationship of fungi parasitic upon fodder to certain cattle diseases. In collaboration with the Imperial Agricultural Bacteriologist an examination was conducted

* This work will perforce stop during the war.—F. J. F. S.

on the fungi concerned in the fermentation of rice in the production of indigenous beer. The chief fungi present were *Mucor Prainii* Nech., *Mucor javanicus* Wehm., *Cladosporium Chodati* (Nech.) Sacc., *Rhizophous Cambodja* (Chrz.) Vuill.

VI.—PROGRAMME OF WORK FOR 1914-15.

(1) *Research and experimental work.*—The investigation of some diseases of rice will be continued. The present stage of the investigations is given in *Pusa Bulletin* No. 34, 1913 "Diseases of Rice" and *Memoir, Botanical Series* VI, No. 2, 1913 "A sclerotial disease of Rice." The work will be continued particularly with a view to filling up gaps in our knowledge of the life-history of the organism which causes "ufra" disease, to the explanation of the apparent immunity of transplanted paddy to this disease, and to testing methods for its control. An obscure diseased condition of rice, known in parts of Bihar as "chatra," will be studied. Both these are major investigations. With regard to the other diseases of rice, none appear at present to be of great practical importance, and the investigations will be confined chiefly to the life history of the parasites concerned.

The investigation of the fungus diseases of sugarcane will be continued. Two *Memoirs (Botanical Series* VI, Nos. 5 and 6) containing the results of the work up to date, were published in 1913, and deal with the methods of infection and control in red rot of sugarcane, and with the symptoms and cause of three undescribed cane diseases, two of which have been sometimes confused with red rot. Future work will, for the present, be considered as of minor importance and will include a more detailed study of one of these diseases, "collar rot," and its connection, if any, with the sereh-like degeneration of cane known in several parts of India, and also the extent to which soil infection occurs in red rot.

The study of the wilt disease of cotton and sesamum will be continued on the lines described in *Memoir*,

Botanical Series II, No. 9 "Wilt disease of Pigeon pea." No results of sufficient interest to justify publication have yet been gained in connection with these diseases, which are of sufficient importance to be considered as amongst the major diseases of crops in India.

The work on potato blight recently commenced may also require to be treated as a major investigation if the disease recurs in the Gangetic Plain, where there was a severe outbreak last year. It is hoped to study the growth of the parasite in artificial culture and in particular to investigate its temperature relations as it is in this direction that its control appears to be most hopeful. As minor investigations the study of some allied parasites will be undertaken. Two of these have been studied in detail and the results published as *Memoirs, Botanical Series V*, Nos. 4 and 5, 1913, since the submission of the last programme to the Board.

The opium poppy blight has usually been believed to be caused by an allied fungus to the last mentioned group, but evidence was obtained last year, when the disease was severe, which suggests that this is not the case, but that the cause is a species of *Rhizoctonia*. The investigation of this disease will be directed to ascertain the true cause and to test methods of control. The study of other diseases caused by *Rhizoctonia* will be continued as occasion arises, and as sufficient material has been accumulated to undertake a more detailed study of this genus, it will be considered a major investigation.

The study of certain green parasites of crops will be continued. Little is known of these parasites in India and it is of importance to investigate their biology, particularly with reference to possibilities of checking the damage caused by them. The investigation has only recently been commenced and has not yet given any definite results.

Some preliminary work on soil fungi has been commenced and it is hoped to develop this as time permits, particularly with a view to elucidate the action of

fungi in assisting in the decomposition of organic matter. The subject may prove of interest in connection with green manuring, but it is not possible, as yet, to indicate on what lines it will develop.

A number of minor investigations of diseases of crops and fruit trees are in progress or projected. New work of this nature continually arises and it depends on the time available for their study and the relative importance of the disease as to whether they become major or minor items of the work of the section.

(2) *Training*.—This will be continued on the lines indicated in the Prospectus. Short courses will also be given if any students of the Institute wish to attend.

(3) The routine work of advising on plant diseases will be continued and assistance will be given as usual to Provincial Departments of Agriculture, the Forest Department, Planters' Associations and the general public.

(4) It is hoped to make further progress with the publication of descriptive lists of Indian fungi in the series "Fungi Indiæ Orientalis," of which four parts have already been published in collaboration with Messrs. H. & P. Sydow of Berlin, and a fifth is in preparation. The extension of this series to include the groups not yet dealt with is the most important part of the systematic work of the section and is very necessary. Minor papers on systematic mycology will also, probably, be published.

VII.—PUBLICATIONS.

Butler, E. J. . . . Ufra disease of Rice. *Agri. Journ., India*, VIII, July, 1913 (also Bengali translation).

Butler, E. J. . . . Diseases of Rice. *Bull. Agri., Res. Inst., Pusa*, No. 34, 1913.

Butler, E. J. . . . Tikka disease and the introduction of exotic groundnuts in Bombay Presidency. *Agri. Journ., India*, IX, January, 1914.

Butler, E. J. . . . Notes on some rusts in India. *Annales Mycologici*, XII, 1914.

Butler, E. J. Report on Mycology for 1912-13 for Board of Scientific Advice.

Butler, E. J., & A. Hafiz Red Rot of Sugarcane. *Mem. Dept. of Agri., India*, Bot. Ser. VI, No. 5, October, 1913.

Butler, E. J., & A. Hafiz Some new Sugarcane diseases. *Mem. Dept. of Agri., India*, Bot. Ser. VI, No. 6, December, 1913.

Butler, E. J., & Saccardo, P. A. Fungi Indiei. *Annales Mycologici*, XII, No. 3, 1914.

Shaw, F. J. F. Sclerotial disease of Rice. *Mem. Dept. of Agri., India*, Bot. Ser. VI, No. 2, July, 1913.

Shaw, F. J. F. The Mahali disease of Areca-nuts. *Leaflet No. 7 of 1913 of the Dept. of Agri., Madras*.

Shaw, F. J. F., & McRae, W. The Bud Rot of Coconuts in the Malabar District. *Leaflet No. 10 of 1914 of the Dept. of Agri., Madras*.

Shaw, F. J. F., & S. Bud Rot of Coconuts in Malabar. *Agri. Sundararaman. Journ., India*, April, 1914.

Shaw, F. J. F., & S. Bud Rot of Coconuts in Malabar. *Annales Mycologici*, XII, No. 3, 1914.

REPORT OF THE IMPERIAL ENTOMOLOGIST.

(T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.)

I.—CHARGE AND ESTABLISHMENT.

Mr. H. Maxwell-Lefroy resigned his appointment as Imperial Entomologist from 1st December 1912 and I was nominated to succeed him and my services were transferred to the Government of India from that date but I was retained temporarily in Madras until relieved there, so that it was not until 1st December 1913 that I actually took over charge as Imperial Entomologist. Mr. A. J. Grove, Supernumerary Entomologist, who was in temporary charge of the section pending my return from Madras, was lent to the Punjab from 27th January 1914 to carry out work on grain pests and cotton bollworm, and remained in the Punjab until the close of the year under report. Mr. C. S. Misra, First Assistant, was on duty throughout the year and has carried out his work in a uniformly satisfactory manner; he has given his attention especially to the examination and record of the crop-pests of the cultivated areas of the Pusa Estate, to the collection of information regarding fruit-pests, and to the study of cotton bollworms and their parasites, of *Pyrilla* and of *Aleurodidae*. Mr. C. C. Ghosh has been employed in the usual routine work of the rearing of insects in the Insectary. Mr. G. R. Dutt, as in previous years, has looked after the economic records and the *Hymenoptera* Collection. Mr. D. Nowroji has looked after the General Collection of Insects, especially the *Coleoptera*. The duties of these two assistants must naturally tend to increase considerably every year as the collections and records are augmented. Mr. M. N. De is borne especially for Sericultural duties and has been in charge of the silk work during the year and has carried out his duties with zeal and intelligence.

II.—TRAINING.

Two students were under training in General Entomology during the year; one came from Travancore and completed his course on 30th September 1913, the other from Assam finished his training on 31st October 1913. No students are now under training; one man was to have been sent by the Punjab in June 1914, but it is understood that his course has now been postponed for a year. As all the provinces have now got a staff of trained assistants it is obvious that only occasional students are likely to be received at Pusa for training in Entomology, as there is no sign of any demand for a knowledge of this subject for its own sake and except as a means for Government employment. The lack of demand for training has, however, this advantage, that the Pusa staff is able to devote more time to research work.

III.—TOURS.

I was away from headquarters in Madras from 1st December 1913 to 8th January 1914, attending the meeting of the Board of Agriculture and going over collections and records at Coimbatore. On 6th March I went to Nagpur to examine the Agricultural students in Entomology and returned on 15th March. On 22nd March I left Pusa again for Madras to examine the students there and to get in touch with the new Government Entomologist. I also visited Ceylon to see the local arrangements regarding plant imports and Coorg to see the extent of spread and control of the green scale on coffee, and returned through Bombay to see the entomological work there, arriving back at Pusa on 8th June. During this tour I also saw the Customs Officials at various ports which have been proposed as entry ports under the new Pest Act. and collected considerable information regarding plant imports into India. Mr. Grove toured in the Punjab from 8th August to 13th September, and visited Sabour in October and Siripur in November. Mr. Misra was sent on special duty to Karauli State from 2nd November to 6th December to establish the Lac Industry there; he also toured in Madras, Bombay and

the Central Provinces from 25th January to 12th March with the especial object of obtaining information on pests of fruit-trees. Mr. Ghosh visited Darjiling and Naini Tal in September to see the methods of bee-keeping practised there. Mr. De visited Assam in February to obtain information regarding Eri and Muga silkworms.

IV.—PROVINCIAL WORK.

The entomological work of the Provincial Departments of Agriculture is to a large extent supplementary of and interdependent on that done at Pusa. Except in Madras, none of the Provincial Entomological Assistants are placed under the control of a qualified expert able to check their work locally and under such circumstances a Central Institute can fulfil a very useful function in checking and correlating their work besides acting as a centre for information regarding life-histories, records of occurrence and means of control of insect pests. Some provinces have taken full advantage of this fact in the past and have worked in close touch with Pusa; others have not done so hitherto, but it is hoped that, as a result of efforts now being made, they may do so in future.

In Madras the Decean Grasshopper work was continued in the Bellary District but the failure of the rains at the commencement of the monsoon caused the destruction by drought of the early-sown crops in the area attacked so that the control-operations proved abortive on this account. The Entomological Laboratory fittings and the Insectary at Coimbatore were completed during the year and the collection rearranged in the new boxes. A large amount of information on insect pests was amassed and much of this was utilised for a book on South Indian insects which was written and completed by myself before leaving Madras. My successor, Mr. E. Ballard, who had been Government Entomologist in Nyasaland for the preceding two years, joined his new appointment at Coimbatore in January 1914 and has since been engaged in familiarizing himself with the insects of the Madras Presidency.

In Bombay there are now only two Entomological Assistants employed, one as Lecturer in the Agricultural College at Poona, the other in the Northern Division of the Presidency. The Third Assistant, who was stationed at Dharwar in the Southern Division, has been transferred to the Agricultural Section and his post has not been filled. Special attention has been paid to the occurrence and control of *Schænobius bipunctifer*, which is a serious pest of rice.

In the Central Provinces two Entomological Assistants are employed, one for teaching at the Agricultural College at Nagpur, the other for fieldwork and demonstration. The latter made numerous notes on insect pests and exhibited show-cases and lectured and demonstrated control-methods at numerous Agricultural shows to audiences aggregating about nine thousand cultivators. Large numbers of *Canthecona furcellata*, a Pentatomid Bug predaceous on caterpillars, were bred and liberated in cotton and gram fields to check attacks on these crops by caterpillars.

In the United Provinces, demonstration was made in the Farrukhabad District of methods of storing seed potatoes to avoid attack of the Potato Moth (*Phthorimaea operculella*) which is now widely distributed in these provinces, though as yet it has apparently not reached the Hill Districts.

In the Punjab the work done has mainly been on pests of cotton and stored grain. Living specimens of *Rhogas*, a Braconid parasite of the cotton bollworm (*Earias*), have been supplied from time to time from Pusa.

In the North-West Frontier Province one Entomological Assistant works under the Agricultural Officer. The sugarcane crop is reported as badly infested with borers this year, over 50,000 egg-clusters having been picked from one experimental plot of six acres. *Gelechia gossypiella* is stated to have done considerable damage to last year's

cotton crop, but it is observable that late-ripening varieties were attacked most severely, local cotton (*Gossypium neglectum*), which ripens and is picked before the middle of October, practically escaping attack. Living specimens of *Rhogas* were supplied from Pusa and set free in the cotton-fields of the Agricultural Station at Tarnab, but it is doubtful whether they have established themselves. A Jassid bug, attacking grape-vines in the vineyards situated in the lower parts of the Peshawar Valley, has also been under investigation.

In Bihar the entomological work has always been done in close touch with Pusa and this has been the result of policy rather than of the contiguity of the two localities. An account of the more important pests was prepared some three years ago and was issued at the close of the year under review as a Crop pest Handbook. The most important work undertaken has been the control of *Agrotis ypsilon* on the Mokameh Tal and the storage of potatoes. At Mokameh a regular campaign was undertaken and during the season 39,000 caterpillars were picked and destroyed on the high lands, whilst 34 traps destroyed 893,320 moths of which about 41 per cent. were females. On account of abnormal flood conditions and other factors, the attack was unusually serious, some 5,000 bighas of *rabi* pulse crops being destroyed. A similar campaign was undertaken against the same insect for the first time at Colgong and Ghogha, where 21 traps destroyed 43,874 moths whilst 337,600 caterpillars were handpicked from the high lands which were first attacked; the attack, which normally extends over an area of 8,000 bighas, was reduced to a nominal damage over about 20 bighas as a result of the above-mentioned efforts. The storage of seed potatoes has of late years presented great difficulties in Bihar, as in other provinces, as a result of the introduction into India of the Potato Moth (*Phthorimaea operculella*). Storage under dry sand has proved fairly effective in the districts South of the Ganges and Government godowns were started at Bihar, Bhagalpur, Colgong and Sabour in order to demonstrate the practicability and

advantages of this method. Storage was done satisfactorily in all these places and the method of storage is becoming popular amongst the cultivators and others interested. That this method is actually being adopted is shown by the fact that at Patna and Bihar in 1913 no less than 1,520 persons stored 122,285 maunds of potatoes under sand, as compared with 16,613 maunds stored by 399 persons in 1912, and 8,000 maunds by 200 men in 1911. Another pest of stored potatoes in Tirhut is a Tingidid bug (*Recaredus* sp.) and experiments are being made to find a successful method of control, as sand-storage is found to induce rotting of the potatoes in the damp climate of Tirhut.

In Bengal the Entomological staff only includes one Collector who is employed under the Government Botanist. He was chiefly occupied in dealing with pests of rice and also attended the Agricultural shows at Barasat, Khulna, Suri, Brahmanburia and Kamarchar where he explained insect pests and their life-histories and demonstrated the use of control methods.

The Entomological Assistant in Assam only went to his province in November 1913 after completion of his training at Pusa.

In Burma there is one Entomological Assistant, who was chiefly employed on the collection of information regarding insect pests of rice.

V.—WORK AT PUSA.

Investigation into the life-histories of injurious and other insects was continued, the following insects being those of which at least complete life-cycles were obtained:—

- Pyrrita aberrans.*
- Aleurodes bergeri* and *A. citri*
- Actaeomorpha crenulata.*
- Eublemma olivacea.*
- Odoiporus longicollis.*
- Virachola isocrates.*

An unidentified Dermestid beetle on Stored Wheat.

Harpactor costalis.

Canthecona furcellata.

Syntomis cyssea.

Tarugama siva.

Polyocha saccharella.

Dolycoris indicus.

A Psocid on *Loranthus*.

Figures of the various stages of most of these insects have been drawn and will be utilized for Memoirs on the insects concerned.

The subject of natural enemies (parasites and predators) of crop-pests is of great importance in India and a start is being made to collect information on the subject. Special attention has been paid to the parasites and hyperparasites of cotton bollworms (*Earias* spp.), of *Achaea melicerta* and of *Pieris brassicæ*. Parcels of *Earias* larvæ parasitized by *Rhogas lefroyi* were sent to the North-West Frontier Province and the Punjab to endeavour to assist control of this pest. There is no doubt that in the near future such control-methods will be found to be applicable in many cases, especially in the case of introduced pests, and we are already receiving numerous inquiries from abroad (notably America and Italy) regarding parasites of destructive crop-pests, and an attempt is being made to procure a parasitized colony of *Aleurodes citri* for export to Florida where this insect has done vast damage to the orange industry. In this connection it is of interest to note that an apparently identical parasite has also been reared from *Aleurodes ricini*, which occurs commonly on Castor in India, and specimens of the two parasites have been sent to Washington for exact determination, as their identity, if established, will be of practical importance.

Attempts have been made to trace *Agrotis ypsilon* through the hot weather and rains, as it is not known in what stage the insect passes this period on the Mokameh Tal, if it is actually present then at all. Incidentally, in

collecting the larvae, it was found that they are preyed upon extensively by a Carabid beetle (*Broscus punctatus*).

The study of insects affecting stored grain was continued by the Supernumerary Entomologist, and the life-histories of *Aethriostoma undulata*, *Tribolium castaneum (ferrugineum)*, and *Rhizopertha dominica* have also been worked out by Mr. Nowroji.

Special attention has also been paid to the insect pests of paddy and sugarcane, and large numbers of insects have been bred out and their study will be taken up when sufficiently long series are secured both from Pusa and the provinces. It may be noted here that paddy stubble, collected in the fields at Pusa in February, showed that about forty per cent. of the stalks contained borers.

Work on Termites has been continued and determinations of upwards of four hundred lots of these insects were received from Professor Nils Holmgren, of Stockholm; the identification of this material not only increases by some twenty species the list of known Indian forms, but will prove of great assistance in the discrimination of the various kinds found to do damage and in the writing up of a large accumulation of notes on their bionomics and occurrence. Wood treated by various processes was examined in February 1914 and some of the pieces of Powellized wood were found to be attacked by *Microtermes obesi (anandi)*. This process is therefore not so infallible as has been claimed. Examination of some of the other series indicated that exemption from attack depends on the variety of the wood itself as well as on the method of treatment and in addition to the preferential tastes shown by the various species of termites locally prevalent: this point scarcely seems to have received proper consideration hitherto and it is proposed to initiate further series of experiments.

The green scale, *Coccus viridis (Lecanium viride)*, which has proved such a serious pest of coffee in Ceylon and Southern India, first invaded Coorg in 1913 and bids fair

to become a serious pest there also. In May 1914 I visited Coorg, saw the affected areas and advised the planters on the subject. The scale was found to be parasitized to a very slight extent by a minute Chalcidid, apparently a species of *Coccophagus*, which has been sent to Washington for exact determination.

A consignment of *Microsporidium polyhedricum* in dead silkworms was received from the Government Entomologist, Egypt. This organism is said to be effective in the control of *Prodenia litura* in Egypt, but experiments at Pusa, conducted with the help of the Imperial Agricultural Bacteriologist, gave negative results with silkworms and larvæ of *Prodenia litura*.

An event of the year which deserves mention in this report is the passing of the Insect Pests Bill (Act II of 1914) for controlling the importation into British India of living plants which might otherwise bring in noxious insects in the future as they have done in the past. A Notification has been issued regarding certain specified crops, but this is aimed rather at the importation of fungal diseases, and a second Notification will doubtless be issued regarding all plants which are likely to bring in insect pests.

Under the Wild Birds and Animals' Protection Act, 1912 (Act VIII of 1912), a Notification regarding the protection of certain useful species of Wild Birds has been issued by the Governments of Bihar and Orissa and Madras, but I am not aware that any other Local Government has as yet issued a Notification under the Act.

Silk.—Six students completed a short course in Eri and Mulberry silkworm rearing. Besides these, Mr. Ayoob Ahmad of Mirpur, Azaigarh, Babu Shashi Bhusan of Shahabad and the Superintendent of Industries in Banganapalle State were given practical instruction in Sericulture and Silk-dyeing. Amongst the visitors were also the Consul for Italy and Rai Bahadur B. C. Basu, who had been deputed specially to inquire into Sericulture in

Assam, both of whom wished to acquire special information regarding silk-work.

A multivoltine mongrel race of mulberry silkworms was established after many trials, and this at first yielded silk superior in quality and quantity to those of the Bengal multivoltine races, but this strain unfortunately began to deteriorate after the fourteenth generation and in the sixteenth generation there was practically no difference between the mongrel race and the ordinary Bengal multivoltine races. Experiments are being continued to try and obtain a stable race. The univoltine mulberry silkworm eggs which were sent for cold storage to Ramgarh (Nainital) Muktesar and Calcutta, gave satisfactory results. Mulberry silkworm eggs were supplied to 157 rearers and eri eggs to 145 rearers, and mulberry seeds and cuttings to 14 applicants. Forty pounds weight of eri cocoons were supplied to Messrs. Killick, Nixon & Co., of Bombay, for testing in the spinning mills in England. There is still difficulty in disposing of the small lots of eri cocoons which are offered for sale by small rearers. Silk exhibits were sent to Exhibitions held at Muzaffarpur and Monghyr, materials for exhibits were supplied to Mr. Audinarain-swami, of Madras, who was awarded a gold medal for his exhibit, and materials for ten sets of silk exhibits were supplied to the Deputy Director of Agriculture, Bengal. Instruction was also given by correspondence in silk-dyeing, bleaching, silkworm rearing, spinning, reeling, and weaving. A Bulletin on Mulberry Silkworms and Silk was published during the year and a Bengali translation of this is now in the press, whilst another Bulletin on "How to improve Silk-reeling in Bengal" has been written and submitted for publication. A paper on Eri Silk was read at the All-India Industrial Conference held at Karachi in December 1913 and articles on Tasai and Mulberry Silkworm rearing were contributed to the vernacular magazines "Grihastha" (Calcutta) and "Krishi Sampada" (Dacca). Approximately Rs. 400 were credited to the

Treasury during the year, being sale proceeds of silk made at Pusa.

In Madras a fieldman has been employed on special duty on Sericulture in the Kollegal District; he has given practical instruction to the mulberry-silkworm rearers and a short vernacular leaflet with practical instructions for rearing has been prepared. In Bihar, the rearing of eri silkworms at Sabour was more successful during the year under report than in the previous season; eggs were distributed to a large number of zamindars and cultivators in the Bhagalpur District, but the usual difficulty was found regarding the disposal of cocoons by the rearers on a small scale. In the Central Provinces some univoltine seed, received from Italy in October 1913, began to hatch in December and the worms, which were reared from January to April, thrived well and the resultant eggs have been kept in cold storage for the next season. In the United Provinces Mr. Akhtar Mohammad Khan has been on special duty at Shahjehanpur in connection with the eri silk work and in Assam Rai Bahadur B. C. Basu has been placed on Special Sericultural duty.

Lac. During the two Lac seasons (October and June) at Pusa, upwards of 200 *Ber* trees were inoculated and the crop scraped, washed and sold. There were no students for either course and this is doubtless due to the fact that practical instructions have been given in the Bulletin on "The Cultivation of Lac in the Plains of India," of which the first edition of 1,500 copies was soon exhausted and a second revised edition was prepared and issued during the year; a Hindi edition is now in the press and an Urdu edition is in preparation. Brood-lac was supplied to twelve applicants and answers were sent by correspondence to numerous inquirers in various parts of India. The Superintendent of Industries in Banganapalle State spent a week at Pusa picking up details of the Lac work and was subsequently supplied with seed to commence work on an experimental scale. The services of Mr. C. S. Misra were also requisitioned by the Karauli State to start and supervise

Lac-culture in that State; he obtained *Kusumb* brood-lac from Rewah, selected the localities in Karauli where work was to be commenced and started inoculation of the trees selected. After doing this Mr. Misra visited Sind to obtain *Babul* brood-lac and to study the methods of propagation practised in that district. Collection of Lac specimens by the Forest Officers continued throughout the year, the series being, however, now completed for some districts; 42 parcels were sent out and 29 parcels were received.

In the provinces little lac-work seems to be done. In the Central Provinces the inoculation done in June 1912 proved unsuccessful and this was therefore repeated in October 1913, but the insects did not thrive well.

Bees.—At Pusa the last of the imported Italian queens died in July 1913. At that time there were two colonies headed by queens reared at Pusa and in August a third queen was reared and fertilized, but in the course of the year all the three queens failed and the bees died out. The proper fertilization of the queens seems to be at present the main difficulty in establishing these bees in the Plains; the workers seem to do well and it is comparatively easy to rear new queens as required, but these are usually snapped up by insectivorous birds during their marriage-flight or, if they survive this, fertilization does not seem to have been sufficiently thorough, as after a few months they commence to produce drone-brood only. Experiments have been continued with the Indian Bee (*Apis indica*) and a mill for preparing foundation-wax for this bee has been procured, as have also queen-excluders of special size, so that these bees can now be kept in bar-frame hives under modern conditions. A Bulletin on Bee-keeping has been prepared and submitted for publication. As Apiculture in the Plains is still in an experimental stage no regular course of instruction in Bee-keeping can be given, but Entomological Students and interested Visitors have been given such information as they required.

VI.—MISCELLANEOUS.

The correspondence work of the Entomological Section continues to be very heavy and the numerous inquiries regarding insect pests, received from all over India, are dealt with as fully as possible. During the year 1,690 letters were issued and 1,385 received, but these numbers do not include a large mass of correspondence and papers dealt with demi-officially.

VII.—INSECT SURVEY.

The collections continue in good order and numerous additions have been made by specimens collected during tours and those sent in by correspondents. Neuroptera were received back named from Mr. N. Banks, Ichneumonidæ from Mr. Morley, and Orthoptera named by the late W. F. Kirby. The Chalcididæ have been sent to Dr. L. O. Howard, of Washington, who has kindly consented to have them determined, and the Rutelidæ to Mr. G. Arrow for his "Fauna" volume on this group. The whole of the collections will be placed in one series, in order that the whole of the information available concerning any one species may be available in one place, and this work has been commenced.

VIII.—PROGRAMME OF WORK FOR 1914-15.

This will follow generally in the lines of work of the current year as outlined in the present report, and will include general investigations of crop-pests, and especially of the pests of rice, sugarcane and cotton, of fruit-trees and of stored grain. A commencement has been made of collection of information for a general book on the crop-pests of India and progress in this will be continued, as also in the publication of information regarding life-histories of pests and coloured plates, of which a large number are now ready for printing. Work and experiments in silk, lac and bee-keeping will be continued, and

new insecticides and insecticidal methods tested as occasion arises. Advice and assistance will be given as far as possible to Provincial Departments and to all inquirers on entomological subjects.

IX.—PUBLICATIONS.

The following publications have been actually published during the year under review :—

Entomological Memoirs.

Vol. V, No. 1. Life-histories of Butterflies, by C. C. Ghosh.

Bulletins.

No. 28. The Cultivation of Lac (Second, revised edition), by C. S. Misra.

No. 29. Eri Silk (Second edition).

No. 39. Instructions for rearing Mulberry Silkworms, by M. N. De.

Agricultural Journal of India.

October 1913. Red spider on Jute, by C. S. Misra.

January 1914. Some Experiments with Maize stored in Bins, by A. J. Grove.

REPORT OF THE IMPERIAL PATHOLOGICAL ENTOMOLOGIST.

(F. M. HOWLETT, B.A., F.E.S.)

I.—ADMINISTRATION.

I was in charge of the section for the whole of the period dealt with in this report. Mr. P. G. Patel was absent on privilege leave for one month and six days from April 14th, Mr. H. N. Sharma for two months and eight days from October 16th, and Mr. J. L. Mitter for two months from October 16th.

II.—EDUCATIONAL.

Messrs. C. S. Swaminath and J. L. Mitter appointed to Pusa by the Medical Research Association, finished their period of training here and have been taken over by the Medical Research authorities. Mr. Mitter has joined Major Mackie in Assam to assist in the Kala-azar investigation now in progress, while Mr. Swaminath is working with Colonel Adie in Kasauli at the transmission of *Halteridium* by flies of the genus *Lynchia*.

III.—RESEARCH.

My personal attention has been largely devoted to an attempt to work out methods of insect-control by examining and taking advantage of the reactions of insects to particular stimuli which seem to influence to a very large extent their more important activities. The lines on which one branch of this work is proceeding are indicated in an article on "The effect of oil of Citronella on two species of *Dacus*" (*Trans. Ent. Soc., London*, 1912, p. 417), and the results so far obtained encourage the hope that considerable improvements in our present methods may result from enquiry on these and similar lines, though these possibilities have hitherto been very largely neglected by entomologists.

Mr. S. K. Sen has been assisting me in the above enquiry and has also worked at the bionomics of mosquitos and particularly of mosquito-larvæ. The calomel method (see Annual Report, 1912-13) has given good results when used on a small scale in the field, and merits attention. Mr. Sen made a very careful investigation of the respiration of mosquitos in all stages, and has contributed an article on the subject to the *Indian Journal of Medical Research*. Publication of various articles by Mr. Patel and myself in the same journal has been suspended until a definite settlement of the question of "medical" work at Pusa. Mr. H. N. Sharma has also worked largely at mosquitos, and has attempted to get at the connexion between the existence of small wounds and abnormal feeding reactions. Mosquitos have been got to feed on red ink, salt solution, and other beverages, but no satisfactory explanation has been arrived at of a very curious fact.

In connexion with Major Holmes' Surra investigation, Mr. Grove, and subsequently Mr. Mitter, visited Kathgodam with the object of assisting the entomological side of the enquiry. This appears to be more complex than was originally supposed, and may necessitate the services of Mr. Patel or myself.

IV.—VETERINARY.

In addition to the Surra investigation at Kathgodam and Muktesar, work on the bionomics of flies likely to be Surra carriers has continued. Mr. P. G. Patel made an extended tour in the Punjab with Colonel Newsom, and was able to give valuable assistance in the work on insect parasites. Mr. Patel has been also working with me on the habits and life-history of lice.

In the course of a tour in Madras I was able to dispel a long-standing supposition that Indian hides are seriously damaged by Warble-flies. These flies seem to be in fact rare in the plains, and an examination of damaged skins, chiefly sheep and goats, showed that the damage known in the trade as "warbles" is really due to the punctures conse-

quent on tick-bites. The rather similar damage called "pori-pori" may be due to the same cause, or possibly to lice, but it was not possible to settle this point definitely.

As Miss Ormerod states that over 40 per cent. of Indian hides are damaged by "warbles," it is as well to know that the injury is due to another cause.

Work is in progress on the egg-laying reactions of blood-sucking *Muscidae*.

V.—FRUIT-FLIES.

Mr. A. Mujtaba has visited Peshawar, the Central Provinces, and Bombay in the course of his work on this group, while Mr. Sen also visited Madras. The life-histories of two new species have been worked out, and a series of life-history memoirs of all the common species is now in course of preparation. The relations between the species and varieties, or local races, are evidently complex, and a complete knowledge and understanding of their bionomics can only come after a great deal of careful study. The spray method of control has proved successful and can be confidently recommended.

VI.—MISCELLANEOUS.

In Mr. Grove's term of office as officiating Imperial Entomologist, I gave some assistance with the work on silk and silk weaving with which I was familiar, and in accordance with the recommendations and enquiries of silk merchants in Bombay and elsewhere made some modifications in our weaving practice in the direction of obtaining a more porous and absorbent cloth of a kind suitable for shirtings and the like. In this Mr. De has been successful.

I corresponded with the Chief of the Board of Health, Isthmian Canal Commission, with reference to Yellow Fever and *Stegomyia*. I forwarded to him two consignments of eggs of our common Indian *Stegomyia scutellaris* to be hatched out on arrival, in order to ascertain whether or not this species can convey Yellow Fever, a point possibly

of considerable importance to India. I have not yet heard the results of the trial.

Identifications of insects for medical officers and others has continued as usual, but presumably this work will be transferred at an early date to the official entomologist of the Medical Research Association.

VII.—PROGRAMME OF WORK FOR 1914-15.

Research as indicated in para. 1, section III, above. It is hoped to complete a work on Indian Flies and blood-suckers based upon the sections written in " Indian Insect Life " on Diptera and other parasites of man and animals, but of a more detailed and somewhat less popular nature.

dantly evident that the information so far obtained forms but a small fraction of what may be derived from further study of the subject: it is also necessary to state that owing to untoward circumstances the quantitative value of the field experiments of the first two seasons was greatly diminished, which makes it necessary to repeat the more important ones. The difficulty of obtaining an area of even soil for experimental plots was well illustrated in the first year, when it was found necessary to discard the whole of one series on account of obvious initial differences between the soils of various plots; in the second year a carefully selected area taken in the middle of a large field proved its unsuitability for anything more than comparisons between adjacent plots owing to waterlogging of portions consequent on heavy rain and inadequate drainage. During the current year (1914) a fresh site has been selected which is free from such inequalities, but again difficulty has been experienced owing to irregular rainfall in June at the time of sowing and the attacks of caterpillars upon the backward plant: the latter has, however, survived, and although the six weeks old crop weighs less than two-thirds of that of the same age in previous years it is hoped that reliable comparative results will be obtained. In addition to these field experiments on the farm an area of one acre has been fenced in, cultivated, and sown with *sanai*, on the south side of the new outside laboratory, and it is hoped that experimental plots on this area laid out in triplicate divisions of $\frac{1}{3}$ acre each will help to provide controls for the field experiments carried out on a larger scale on the farm. In my previous Annual Report it was mentioned that the green manuring experiments for 1913-14 would include a trial of the use of the method of fermenting the green crop before applying it to the land, and at the same time concentrating the manurial action by restricting the treated area although using the whole of the fermented material. The result when such concentration was carried out, the fermented *sanai* being returned to about half the area on which it had been grown, in the case of the following *rabi* crop of wheat

was very apparent as a marked increase in crop, but owing to the waterlogging of part of the area and the consequent interference with the regularity of the series, definite quantitative conclusions could not be drawn as to the relative value of this method.

Small plots in the compound of the outside laboratory of about $\frac{1}{50}$ th acre area were used for qualitative experiments in green manuring, the *rabi* crop being oats; variations in the method of preparing the fermented manure were tested and showed decided differences which are described in the report on the subject for 1913-14 now in hand. It was also found that for this crop on light soil no apparent advantage was obtained by concentration of the manure, improvement of the crop being probably due to the comparatively high availability of the nitrogen content of the fermented material. Further experiments dealing with the application of the method to other crops such as tobacco are in progress during the current season.

In connection with this work a considerable amount of research has been carried out in the laboratory in continuation of that of last year which dealt mainly with the ammonification and nitrification of the buried green crop; further observations on these two points have been made and in addition some fourteen species of bacteria apparently closely connected with the decomposition of buried Sann hemp have been isolated, and their physiological and morphological characters studied. It is remarkable that no one species of bacterium capable of attacking cellulose has been found so far in the general soil complex although the symbiotic relationship of two or more has been shown to produce this result: the opinion expressed in the Bulletin on green manuring published in 1914 that soil fungi probably played an important part in the breaking down of cellular tissue is strengthened by further observation: it is hoped that work on soil fungi by the Mycological Section of this institute may furnish valuable information on this point.

Part of the study of the decomposition of green manure in the soil involved investigation as to the relative rates of formation of humus and nitrate; this enquiry has not yet arrived at the conclusive stage suitable for report.

A considerable amount of work was done in connection with the changes taking place in fermenting green manure; the manurial value of this material appears to be due to the rapid formation of simple nitrogen compounds such as ammonia, from the proteid content; the nitrification of this ammonia, however, is interfered with by the fact of its concentration and also by the presence of soluble organic substances some of which at least are strongly toxic to nitrifying bacteria and in less measure to others; this condition persists so long as the water extract remains acid to litmus which under ordinary conditions of manufacture might extend to as much as six weeks, and renders it necessary to study the conditions under which such manure can safely be applied to arable or other soil. The mode of preparation may also be varied considerably with corresponding differences in manurial action; such differences are apparently correlated with the rate at which the nitrogen content becomes available and are of importance in field practice with reference to the time of application, the nature of the soil, and the nitrogen requirements of the crop intended to benefit by the use of this form of manure.

It is interesting to note that the rapid ammonification which takes place when green manure is placed in water and allowed to ferment was found to be accompanied by the development of large numbers of ciliates, flagellates and amoebae, whose presence does not appear in this instance to be prejudicial to the activity of ammonifying bacteria; it may be conjectured that under such conditions as obtain in this case the abundance of organic food would produce a rate of reproduction amongst the bacteria which would more than counterbalance any phagocytic action on the part of the protozoa.

The conditions under which nitrification takes place in soil have naturally formed an important part of the work

of this section during this as in previous years; it was found in connection with numerous experiments made to determine the optimum moisture content for nitrification in various soils, that not only is the amount of water all-important, but that the greatest amount of nitrification obtainable depends upon treatment which takes into account the fact that ammonification is the necessary antecedent to nitrification in the case of organic matter, that this process is furthered by a high percentage of moisture, that high concentrations of ammonia inhibit nitrification, but that such ammonia is absorbed by the soil and can then be nitrified. Experiment showed that the most rapid and complete nitrification of any given quantity of nitrogenous organic matter could be effected in soil by producing anaerobic conditions with water saturation and subsequently draining and aerating; the rapidity with which nitrification takes place under these conditions depends upon the relative completeness of the anaerobic and subsequently of the aerobic conditions. This was the case in all the soils experimented with but may not of course be of universal application. It was found that much more rapid ammonification took place in the case of organic matter kept under anaerobic conditions in soil than when free aeration was allowed, whether such anaerobic conditions were produced by water saturation, or replacement of air by nitrogen or carbon dioxide or simply by tightly closing the vessel containing the soil. At the same time toxins were produced which not only inhibited nitrification before the ammonia concentration was sufficient to do so, but afforded water extracts which were toxic to seedlings and to bacteria; subsequent aeration removes this toxic condition and the formation of nitrates takes place, the ultimate result being a high percentage of nitrification of the nitrogen of the organic matter; this apparently represents the cycle of changes in the case of the fermentation of green manure described above; its application to field practice is now being studied.

In connection with the nitrification of green manure it was found that a loss of nitrate invariably occurred between

the 8th and 12th weeks of the process in the laboratory; a considerable amount of work has been done with the object of discovering whether this loss could be accounted for by correlating it with the gradual evaporation of soil water; the enquiry is not yet sufficiently complete for conclusive report, but it seems certain that the change noted is due to variation in the water content of the soil rather than to seasonal variation in the functions of the soil flora.

Experiments were made to determine the effect upon nitrification of varying the quantity of nitrogen as organic matter added to the soil; it was considered probable that any excess above the optimum would retard or even inhibit nitrification, but that the optimum might vary considerably with different soils, and also in the same soil under different conditions. An unexpectedly high optimum was found for mustard cake in Pusa soil, namely, one per cent. of the soil weight, but it was shown that the high lime content of this soil was mainly responsible for this high figure, and that in soils such as the average tea soils of Assam, with less than one per cent. of lime, a much smaller quantity of cake would fail to nitrify at the normal rate. A study was made of the progress of decomposition of cake in soils varying in lime content, by periodic estimations of the loss on ignition, humus, ammonia and nitrates; it was found that decomposition was rapid in proportion to high lime content, although in time the soil lower in lime attained the same nitrate concentration.

Isolation of nitrifying organisms from Indian soils was continued with special reference to a nitrite forming organism hitherto undescribed, the isolation of which by Mr. Joshi, 1st Assistant, is still in hand.

Azotobacter.—A number of soils was examined for *Azotobacter*, which was found in those from Naupada, Vizianagram, Waltair, Tuni, Samalkota, Ellore, Walajah Road, Bowringpet, Jalarpet, Bangalore, Darjeeling and Cawnpore.

A series of determinations of amounts of nitrogen fixed in liquid culture media inoculated with Pusa soil week by

week, and which is still in progress, shows small irregular variations. The amounts are of the same order as those obtained by Ashby at Rothamsted and by Sackett in Colorado.

Pure Cultures.—The amount of nitrogen fixed by pure cultures of *Azotobacter* isolated from Pusa soil was increased by the additions of basic slag or humus to the ordinary medium but was diminished by the substitution of magnesium carbonate for calcium carbonate. The amounts of nitrogen fixed in the pure cultures are similar to those obtained by other investigators in Europe and America.

Well marked differences were observed in the morphological and cultural characters of species of *Azotobacter* isolated from Pusa, Cawnpore, Darjeeling and Bangalore soils, and the amounts of nitrogen fixed by these also varied.

A few preliminary experiments on nitrogen fixation in the soil were carried out.

The addition of a sac of cane sugar to a plot two square yards in area, resulted in an increase, in the nitrogen content of the first six inches of soil, of nearly fifteen per cent. in 10 weeks.

The stimulation of nitrogen activity by the addition of soluble carbohydrates may possibly be of considerable practical importance in the future. It has been shown by Koch that certain bacteria can form soluble carbohydrates from cellulose which can be used by *Azotobacter* as a source of energy for nitrogen fixation; this action would bring the organic matter content of the soil into immediate relation with its possible gain of nitrogen from the air.

Some interesting results were obtained in connection with work on bacterio-toxins in soil; it was found possible to measure the relative toxicity of various bacterial species to an intermediate form (*B. prodigiosus*) and to one another, by use of plate cultures and the measurement of the rate of CO_2 formation in solid and liquid media, and the effect upon the latter of the antagonism or symbiotic action as

the case might be. Marked instances of antagonism and symbiosis were found, and the production of toxins was demonstrated: the methods in use might perhaps be employed to advantage in connection with the investigation of the physiological functions of pathogenic organisms.

Some further work on bacterio-toxins in soils was carried out in connection with the sewage-treated soil samples sent for examination by Mr. Allen of Nagpur. Work on these soils was discontinued at the request of Mr. Allen as the sewage treatment scheme on the Nagpur experimental farm is not yet in complete working order.

IV.—SPECIAL ENQUIRIES.

Potato Rot.—The enquiry on this subject referred to in my previous report is not yet complete, but has been continued throughout the year in order to gain further and fuller information upon various points in connection with the physiological functions of the organisms involved, and the probable distribution of the latter in soil or elsewhere; this information is necessary in order to frame effective preventive measures: reports of the occurrence of tuber rot in store continue to arrive from various parts of India, and numerous samples have been examined, in many instances the rot is due to fungal and not to bacterial attack, as described by the Imperial Mycologist. A report will be issued shortly.

Bákhar.—At the request of the Assistant Commissioner of Excise for Bengal, Bihar and Orissa, and Assam I undertook to investigate the biological factors in connection with the fermentation of rice beer, with a view to determine the feasibility of controlling the manufacture of the ferment, which is at present in the hands of a peculiarly unsuitable class, generally hillmen, who make the ferment or Bákhar according to time-honoured traditional methods of more antiquity than precision. The result of the present state of affairs is a great variation in the quality of the fermented liquor, due to the presence in the Bákhar of

numerous species of ferments, and in the rice beer itself there may be deleterious substances derived from the same source. It is thought that the manufacture of the Bákhar or yeast might with advantage be controlled in order to provide brewers with a reliable ferment of uniform composition and action, and examination of samples of this material from various sources shows that the fermenting organisms present differ widely in character and effect.

The fermentation of rice differs from that of barley in one important respect, in that the rice as a consequence of husking loses its power of germination, and with it is also lost the natural change from starch to sugar produced by the enzymes formed during this process; this change in the case of barley is characteristic of the operation known as malting, which results in the change of the starch of the grain into sugar, a necessary antecedent to fermentation by yeast. In the case of rice it is therefore necessary to produce the change of starch into sugar known as saccharification, by the addition of some form of saccharifying ferment which will provide the enzyme diastase by which this change may be brought about. Barley grain on germination produces diastase which under suitable conditions converts the starch of the grain into sugar, the grain thus altered in composition being known as malt; the same result is obtained with rice by the addition of Bákhar which contains various fungi or moulds whose natural growth on a starchy medium is accompanied by the secretion of diastase. The efficiency of a sample of Bákhar (which is made up and sold in the form of small greyish white cakes of about one ounce in weight) will therefore depend firstly upon its containing an efficient diastase-producing fungus, and examination has shown that the samples collected from various sources differ widely in respect to the kinds of fungi present and their correlated diastatic power with regard to rice starch. When the Bákhar cake is powdered and mixed with rice which has been prepared by moistening, the fungi present form mycelial growth which invades the rice grains and gradually converts their starch into

sugar, the completeness of this result depending upon the suitability of the conditions provided and upon the presence of fungi of adequate diastatic power. A large number of different species of fungi were found in various samples of Bákhar and the rapidity and completeness of the saccharification of the rice starch also varied in accordance with their relative diastatic powers, which were measured in pure cultures. It may be said that no one of the numerous species found compared favourably in this respect with *Aspergillus Oryzae* which is the organism used for this purpose in Japan in the manufacture of "Sake" or rice beer, by the use of the corresponding preparation to Bákhar known in Japan as "Koji;" it is possible that the introduction of *Aspergillus Oryzae* into India might considerably improve the rice beer of this country.

When by the action of the diastase-producing fungi a large proportion of the starch of the rice grain has been converted into sugar, mostly maltose, the next step is the fermentation of the sugar by yeast with formation of alcohol. In the very full and interesting account of the use of Bákhar by J. C. Ray published in the *Journal of the Asiatic Society of Bengal* (Vol. II, No. 4 of 1906) the author ascribes this alcoholic fermentation to the mucors which have already exerted a saccharifying influence on the starch; I have never failed, however, to find yeasts present in Bákhar capable themselves of producing alcohol without involving the supposition put forward that mucors in their vegetative condition secrete diastase but in the reproductive stage produce zymase, the alcohol producing ferment. The yeasts found varied just as the mucors and other fungi were found to do, and as it is a well known principle in brewing and distilling that the variations in physiological characters of the yeasts involved require careful selection of the latter and exclusion of undesirable varieties, it is very probable that the haphazard introduction of unknown numbers of kinds of yeast into rice beer by the agency of Bákhar would afford another point over which control might usefully be exercised.

A third point arises in connection with the use of Bákhar; as will readily be understood, when any organic matter such as moist rice is exposed to the air the ensuing fermentation is likely to be complicated by the presence and activity of bacteria; in the case of beer brewed in Europe from barley-malt and hops, the value of the latter depends upon their content of lupulin with its associated "hop resins" which act as preventives of bacterial action; Bákhar contains many substances the inclusion of which probably originated in an attempt to prevent putrefactive changes, although now they form merely parts of the tradition or trade secret handed down without knowledge of their specific function, or of the fact that whilst the mouldiness aimed at is produced by fungi, the putrefaction sometimes resulting is due to bacteria.

Chillies, ginger, and the bark and roots of various plants are among the substances incorporated with the ground rice to form Bákhar cakes; so far the function of the various substances examined appears to be to restrict the growth of bacteria during the earliest stages of infection of the rice to be fermented until the growth of the mucors has become strong enough to suppress bacterial competition, and in this respect they resemble the hop resins in action.

Many of the substances added to Bákhar by the makers are no doubt intended to produce other effects which would, however, be confined for the most part to the beer and would not appear in the distilled spirit; it has been reported that *Datura* and *Aux. Vomica* are sometimes used in this way and it is natural to suppose that the reputation of a Bákhar maker might be enhanced amongst a certain class of his clients by such reprehensible practices. Specimens of a plant said to be a necessary ingredient of Bákhar as made in the Darjeeling district, have been sent to me for examination; this plant is known to the Limboo tribes as "Wadinghangma" and to the Nepalese as "Bhimsen pati;" it has been identified by the curator of the Lloyd Botanic Garden in Darjeeling as

Polygala arillata; the bark of the roots afforded a decoction, the antiseptic properties of which are now under examination.

Biological Analysis of Soils.—

Reh Soils.—Samples of "Reh" soil received from the Agricultural Chemist to the Government of the Punjab were under biological examination and formed a subject of study for Mr. Barkat Ali, a student from the Punjab who is undergoing training in soil bacteriology in this section. Several interesting facts were discovered as to the effect of lixiviation upon the flora of these soils, and the conclusion was arrived at that the normal processes of ammonification, nitrification and nitrogen fixation would be the natural consequence of removal of the excess of salts from the soil by this means; Mr. Barkat Ali has furnished an excellent report upon his work which encourages the belief that a well trained chemist can acquire sufficient knowledge of the methods of biological analysis as practised in this laboratory to enable him to carry out such work satisfactorily without excessive supervision after a two years' course of instruction.

Biological analyses of soils from Cawnpore, Sind, Assam and Nepal were carried out and reports upon them furnished; the method used is still under revision owing to the necessity for variation in accordance with the character of the soil and the information desired.

V.—PROGRAMME OF WORK FOR 1914-15.

Major Subjects.

- (1) Nitrification.
- (2) Nitrogen fixation.
- (3) Biological Analysis of soils.
- (4) Investigation of effects of management upon the constitution of the Soil Complex.
- (5) Green Manure experiments.

Minor Enquiries.

Potato Rot and other Plant Pathogens.
Bacterio toxins in Soils.

VI.--PUBLICATIONS.

Acting in conjunction with the Imperial Agriculturist I made a series of tours as detailed above with the purpose of investigating the conditions under which dairying is being carried on in India at the present time, and furnished a report dealing with this subject. (Published as appendix F to the Proceedings of the Board of Agriculture in India held at Coimbatore on the 8th December 1913 and the following days.)

A Bulletin on Green manuring (Pusa Bulletin No. 40) recording the experimental results of the first season's work on this subject was published.

REPORT OF THE IMPERIAL COTTON
SPECIALIST.

(G. A. GAMMIE, F.L.S.)

I.—CHARGE AND TOURS.

I held charge of the appointment throughout the year.

Tours.—In July, I visited Simla to assist the Officiating Agricultural Adviser to the Government of India in drawing up a note on the present position of cotton in India; in October I visited the Punjab to advise the Director of Agriculture in consultation with some members of his staff, as regards the present and future lines of work to be undertaken in cotton: in the same month I also visited the United Provinces, where I met Dr. Parr and Mr. Wilson, the Officiating Economic Botanist. In November I visited Sind, in the company of the Director of Agriculture, Bombay, to discuss certain details in cotton cultivation in Sind; in March 1914 I visited the agricultural stations in Guzerat, including Baroda, and the Southern Mahratta Country. The remainder of the time during the year was devoted to the supervision of my own experimental area, to the giving of advice to many correspondents and to arrangements connected with the valuation of numerous samples forwarded for my opinion.

My assistant, Mr. D. P. Mankad, made several tours in Guzerat, Kathiawar, and the Southern Mahratta Country throughout the year.

II.—COTTON IN THE PROVINCES.

Punjab.—After my visits of inspection I furnished the following short note to the Director:—

“ There are three distinct types of American cottons, (a) Upland Georgian, (b) New Orleans and (c) annual form of soft Peruvian. The first, on account of its hardiness and immunity from the attacks of pests, is obviously the

type which should be introduced into general cultivation; the second is less hardy in its nature. It is attacked by Jassids this year and its superiority to Upland is so trifling that it is not worth the risk of being maintained. The soft Peruvian is one of the finest cottons ever grown in India. Its low outturn (in spite of its higher price), however, brings it on a par with Upland. This variety should not be distributed indiscriminately, but should be brought to the notice of farmers of good position who would undertake to give it the necessary care and attention. I would advise that your selections of American cottons be kept down in number. Many at present existing do not differ sufficiently from one another to deserve being kept separate.

As regards the *Deshi* cottons, a survey should be carried out in each tract so that the dominant forms in each can be extracted and tested comparatively as pure types. Those passing the test could be rapidly multiplied on seed farms for distribution to cultivators. It is almost unnecessary to point out that aid should be given in the marketing of the produce until the trade is disposed to pay fair prices spontaneously.

Mr. Milne's discovery that root-rot is caused by a nematode worm is most interesting and I hope he will publish his notes as soon as possible. He has now on his Botanical area pure strains of all the varieties of cotton found in the Punjab. These can be compared with your survey types and time could be saved by making a start from these for your seed farms."

Since writing the above I have heard that the cottons of the districts of Lyallpur, Hissar and Lahore have been surveyed with the following results:—

Lyallpur Tahsil. *Gossypium indicum*, yellow flowered, is the prominent form.

Toba Tek Singh.—*Gossypium sanguineum*, both broad-lobed and narrow-lobed, chiefly near Gojra, and *Gossypium indicum*, yellow flowered, in almost as great quantity.

Sumundri and Jaranwala.—*Gossypium indicum*, yellow flowered, and *Gossypium neglectum*, yellow flowered, in almost equal quantities.

There is everywhere a fairly considerable admixture of the white flowered varieties of *Gossypium indicum* and *neglectum*, and these, popular opinion regards as heavier yielding. Certainly the percentage of lint is higher in the white flowered varieties grown in the Lyallpur Station. *Gossypium sanguineum* is not uncommon in the Lyallpur and Sumundri Tahsils, but it is the predominant type in few villages.

Hissar.—In Hissar, Hansi and Fatehabad Tahsils two-fifths are yellow flowered *Gossypium indicum* and one-fourth to one-third is white flowered *neglectum*. There is no *Gossypium sanguineum*. Cotton is unimportant in Bhiwani and Sirsa Tahsils.

Lahore.—Yellow flowered *Indicum* represents 74 per cent. in Chuman, 78 per cent. in Kasur and 91 per cent. in Lahore Tahsil. In Chuman about 10 per cent. is yellow flowered *Gossypium neglectum*, in Kasur there is a good deal of broad leaved *Gossypium sanguineum* in canal-irrigated villages.

As regards the retention or rejection of American varieties, those retained are of the rough leaved and those thrown out are of the smooth leaved type. 4 F is the chief American cotton on the Station and it has done well everywhere in 1913. The experience of past years shows that American cottons will do well in the colonies under canal irrigation, but they require good land and better cultivation than the indigenous cotton.

United Provinces of Agra and Oudh.—In connection with my tour in these provinces I supplied the following short note:—

“ The lines of work in Dr. Parr’s division are:—

(1) The substitution of the prevailing mixture by the

distribution of the seed of a productive white flowered indigenous cotton. The colour of the flower is of important assistance in maintaining the purity of the type. There are now 20,000 acres of this under cultivation and it may cover the whole cotton area of the division in the course of a very few years. The whole of the seed cotton is ginned under the personal supervision of Dr. Parr, so that the chance of mixture is avoided.

The introduction of this variety teaches the cultivator the value of a pure crop and after he has learned his first lesson a second could be commenced by issuing one of the higher class yellow flowered types, of which one at least shows great promise here.

(2) Regarding the comparative merits of Cawnpore-American and *Bhuri*, Dr. Parr considers that the latter will be more profitable and I am disposed to agree with him. Mr. Burt is, however, of a contrary opinion and the difference can only be settled by making comparative tests.

Previous experience with the Cawnpore-American certainly pointed to the fact that the outturn of American cotton in the United Provinces tends to diminish more and more every year.

(3) Cambodia, on account of its prolonged season of growth, is not at all promising and its cultivation should be given up.

(4) The problems to be solved in the United Provinces are simple, one being the introduction of a longer stapled sort (either American Upland or an Indian hybrid as Mr. Leake is attempting), the other being the substitution of a good-paying pure *Deshi* crop in the place of the mixture, which is now universally grown."

In acknowledging the valuations of samples of cotton which were sent to him, Mr. Burt gave me the following interesting information:—

“ The results of spinning trials at the Elgin Mills and of a valuation by the British Cotton Growing Association show that the Cawnpore-American is valued more highly than the Dharwar American. This difference is, however, not important as the Dharwar variety does not do so well here as regards yield and is much inferior to the Cawnpore variety in ginning percentage. From the valuation based on larger samples I am inclined to think that the Cawnpore-American is more nearly equal to Middling American than Messrs. Tata and Sons' valuation.

“ As regards Boyd and Black Rattler, I am rather surprised to find that Boyd is valued so much above Cawnpore-American, as there was little difference as far as we could tell here. Boyd is, however, one of the most promising of the imported varieties and ginned well. As regards the Black Rattler, it is impossible to say as yet whether this will yield sufficiently well to be worth growing here. It is a later plant than the Cawnpore-American, but has not yet been fully acclimatized. In the meantime we are continuing trials of these and other cottons and at the same time trying to select uniform agricultural types from them. The Cawnpore-American variety yielded well last year on a considerable scale and we have about 500 to 600 acres of this variety this year, having received a guarantee of a minimum price of 6 $\frac{1}{2}$ per lb. for the lint *plus* premium depending on the spot price of middling American.”

During the cropping season I deputed Mr. Mankad to Kathiawar to assist the Assistant of the Economic Botanist, United Provinces, to select types of Kathiawar cottons for experimental purposes at Cawnpore.

Central Provinces.—From valuations made on a set of samples, with details of acreage, outturn and percentage of cotton to seed, supplied by the Akola Experiment Station the varieties grown in Berar fell into the following order

of merit placed by the market value of the clean cotton alone :—

	Rs.
(1) <i>Gossypium neglectum</i> , var. <i>Rosea</i>	60 per acre.
(2) <i>Gossypium neglectum</i> , var. <i>Cutchica</i>	58.5 „
(3) <i>Gossypium hirsutum</i> , var. <i>Bhuri</i>	53.75 „
(4) <i>Gossypium neglectum</i> , var. <i>Vera</i>	51.5 „
(5) <i>Gossypium neglectum</i> , var. <i>Vera</i> (Berar Jari)	45.5 „
(6) <i>Gossypium indicum</i> (Bani)	41.4 „
(7) <i>Gossypium neglectum</i> , var. <i>Sangor</i> Jari	41.12 „
(8) <i>Gossypium neglectum</i> , var. <i>Malvensis</i>	40.5 „

This proves that the cultivators are abundantly justified in their selection of white flowered cottons (of which the two chief head the list), for profit. *Bhuri* follows closely in value and the remaining yellow flowered indigenous cottons fall appreciably in the rear. *Sangor Jari* has solid qualities for its own tract but it cannot compete with the natural denizens of the real cotton soil.

Madras.—A parcel of Cambodia cotton grown at the Hagari Station was the only material submitted to me for opinion during the year. The outturn of *kapas* was 631 lbs. per acre and the ginning percentage was 37.5. In the Bombay market the cotton was valued at Rs. 295. Madras Cambodia of the day standing at Rs. 315. The value of the cotton alone was therefore Rs. 89 per acre, a very satisfactory result.

Bombay.—Sholapur District. Seed of *Gossypium neglectum*, var. *rosea*, was supplied to the Inspector of Agriculture, Sholapur, at the request of the Deputy Director of Agriculture, Southern Division. It was tried at Barsi, where the crop suffered much from want of rain, and at Sholapur, where the crop was very vigorous, perhaps owing to the fact that it was irrigated four times. At Barsi the outturn of seed cotton per acre was 364 lbs. and at Sholapur 1,510 lbs.

Manjri Station.—At this station experiments, with the view of introducing some paying sort of cotton into the

sugarcane tracts are still persevered with and I made an inspection and reported as follows :—

“ I do not consider that there is any hope of success in any of the *neglectum* varieties under irrigation. Broach has already been tried and the results were very unsatisfactory.

“ *Cambodia* seems to be the only good cotton so far that thrives under irrigation and it seems to do well round Poona where conditions are favourable. At Manjri, you have tested it under irrigation for the first time. It has received four waterings which are quite sufficient. As regards spacing, we agree that the best distance is 3 feet between rows and one foot apart in the lines. As to time of sowing, I would advise it to be done as soon as the soil is moist enough after the first rains.”

The total yield per acre was 347 lbs. of seed cotton and the percentage of cotton to seed 40·3. Messrs. Tata, Sons & Co. reported as follows on a sample sent to them for opinion :—“ It has lost in length of staple and is also weak. It shows deterioration. The value is Rs. 265 per candy against Rs. 310 for Madras *Cambodia*.”

The value of the cotton produced is only Rs. 47 per acre. The result is discouraging, but I have advised a repetition of the trial.

Agricultural College Farm, Poona. Although this is not within the cotton tracts, a number of experiments on cotton were conducted under very favourable conditions.

Fourteen small plots of *rosea* were treated with varying mixtures of farm-yard and artificial manures : the control plots being unmanured or treated with farm-yard manure alone.

Messrs. Tata, Sons & Co. reported as follows on the 14 samples submitted to them :—

“ These are almost all alike with the exception of Nos. 1, 7 and 11, which are a little better than the others. Compared with type 23 (Khandesh from Dhulia), they show no improvement, they are a little inferior in length of staple and all

have rough feel. Value of 1, 7 and 11 Rs. 202 each, the rest, Rs. 200 (Fully Good Khandesh standing at Rs. 205)."

This experiment must be continued for a few years before any definite observations can be deduced.

Bhuri was reported on as having long staple but weak fibre.

The fibre of *Cambodia* was found to be very weak.

Of three sets of *rosea*, the first with the seed separated by gravity produced a crop which was found to be better in staple and soft in feel and was valued at Rs. 215; of the second, with seed not separated, the cotton was a little inferior and was valued at Rs. 210. The third from Akola seed was rough in feel and short in staple and was valued at Rs. 205. In this instance, there was a decided advantage gained by separation of the seed before sowing.

The white flowered narrow lobed variety from selections was valued at Rs. 202 equal to that of Nos. 1 to 14, which are of the same type.

Broad lobed variety from selections of *Malrensis* was valued at Rs. 237 against Rs. 235 from seed from Akola.

In Khandesh variety of which fresh seed was received from Dhulia and grown here, the cotton was deteriorated, the staple was very short and resembled Bengal cotton more than Khandesh. Value Rs. 205 (Fine Khandesh standing at Rs. 215).

Karkheli had deteriorated somewhat, valued at Rs. 265 against Fully Good Karkheli at Rs. 275. White flowered broad lobed (*Cutchica*), farm seed, resembles Fine Bengal, valued at the same rate, *viz.*, Rs. 205.

Of the four plant-to-plant selections of yellow flowered broad lobed, *neglectum* type, No. 2 comes first at Rs. 242, No. 4, second, at Rs. 240, No. 3, third, at Rs. 238, and No. 1, fourth, at Rs. 235 (Fine Khandesh of the same date at Rs. 215).

Of the two yellow flowered narrow lobed *neglectum* plant-to-plant selections, one is valued at Rs. 235, the other at Rs. 237.

Of four white flowered broad lobed *neglectum* and three white flowered narrow lobed *neglectum* plant-to-plant selections, one only was valued at Rs. 215 equal to Fine Khandesh; the rest at Rs. 212, equal to Bengal cotton, Rajputana style.

An analysis of the outturns per acre of eight varieties shows that they stand in the following order of their value :—

Serial No.	Name of variety.	Value of outturn per acre of cotton.	Rs	
1	White flowered broad lobed <i>Neglectum (Cutchica)</i>	112.5		
2	Khandesh Local	107.1		
3	Rosea (<i>Varhadi</i>)	95.16		
4	Buri	93.66		
5	Yellow flowered narrow lobed (<i>Fera</i>)	78.87		
6	Yellow flowered broad lobed (<i>Malvensis</i>)	59.81		
7	Karkheli (<i>Indicum</i>)	53.68		
8	Cambodia	34.89		

The white flowered varieties of cottons, as usual, have been proved to be the most profitable. It has also been proved in the Deccan that the duration of these plants is far longer than either in Berar or Khandesh and that the production of cotton also persists over a longer period.

Guzerat.—I supplied the following notes after the inspection of the cottons on the experimental stations in the province :—

“ Surat.—I consider that Selection IA and Selection II are the varieties that should be persevered with, because, of both, the outturn and ginning percentage are above the figures of the local cottons and even above those of the improved crosses already distributed. If the samples of these varieties are submitted to me for valuation, I shall have them thoroughly examined.

" Mr. Bhimbhai informs me that, last year, of No. 1018-P. G., selected Broach, 10,000 acres were sown in British territory and 7,000 acres in Baroda. The Syndicate secured 5,000 bales out of the total of 7,000, the remainder was sold independently by the cultivators to other merchants when the Syndicate ceased buying. This year, 7,000 acres have been put out and one merchant, Mr. Motibhai Raghawji of Surat, is offering Rs. 5 for 960 lbs. of seed cotton over market rate. The Agent of Messrs. Whittle & Co. at Bardoli is also satisfied with the result and they are paying Rs. 4 above the market rate. There is a strong probability that these selected varieties will be maintained by the cultivators, in spite of the withdrawal of the Syndicate's offer.

" Mr. Bhimbhai considers that it will be quite practicable in villages which grow blocks of these selected cottons to form Committees to settle the disposal of the produce without the intervention of middlemen. The new varieties are maintaining the improvement in the ginning percentage.

" Selection IA, out of selected Broach, gives 35.5 or nearly 3 per cent. over the local variety. In the quantity and quality selections No. 2 out of selected Broach, the quality is good and the ginning percentage is 34. This year, it is expected to also stand highest in yield.

" *Cambodia* is abandoned as being unsuitable for the black soil.

" Nadiad.- Cambodia cotton is being attacked by wilt and also by aphides this season. The percentage has fallen to 31. In appearance its lint is much the same as that of *Ladio*, which, being indigenous to the tract, is not so liable to be influenced by abnormal seasons. In the district there is a difficulty in the marketing of the produce, but as many of the cultivators are making their own arrangements for the importation of the seed, the final disposal of the crop should remain in their own hands.

" The cotton crosses on the farm show so very little promise that it would be well perhaps if the officers concerned

drop them and concentrate their attention on the improvement of *Cambodia* and *Lalio*. The increase in the percentage of cotton to seed is the point to be aimed at in the former and the high yielding capacity in the latter is desirable. In my own opinion, *Lalio* will prove to be the cotton most suitable for the tract. During next season *Bhuri*, *Cambodia* and *Lalio* are again to be tested.

"The Superintendent of the Nadiad Farm says that *Cambodia* has been grown on a fairly large scale by cultivators, who now find a difficulty in the disposal of the produce, of which the total amount is still so small that the ginning factories do not care to make any special arrangement for it. If the cultivation extends, assistance ought to be furnished to them from the Department. The cultivators find that the crop is inclined to mature late and they still maintain an open mind regarding the comparative merits of *Cambodia* and *Lalio*."

The following valuations of samples of Guzerat cottons were kindly supplied by Messrs. Tata, Sons & Co. :—

Surat Farm.

Serial No.	Name of sample.	REMARKS.
1	Selection 1A selected	Compared with No. 7 (Surti-Broach), No. 1 (Surat selected) is decidedly longer and stronger in fibre and besides the fibre is even. It can be compared with best Surat except in softness, the feel being rather coarse. Value Rs. 320.
2	Selection 1A General	Fibres rather uneven. Length also shorter than No. 1. Value Rs. 310.
3	1018 P G General	In all respects same as No. 1. In feel it is little softer, rather uneven in fibre, but may be a little bit longer. Value Rs. 320.
4	1027 ALF II selected	This is very long stapled strong fibred cotton and deserves to be encouraged. It is almost equal to Navasari cotton both in length and strength, and though acclimatized for a number of years, it has in no way deteriorated. Value Rs. 335.
5	Do. General	Almost same as No. 4, but variable in length of fibre. Value Rs. 320.

Surat Farm—contd.

Serial No.	Name of sample.	REMARKS.
6	Selection II selected	Compared with No. 1, there seems to be not much difference except that No. 1 is more regular in fibre. Value Rs. 315.
7	Surti Broach	It cannot stand comparison to any of the above 6 samples, being shorter in staple and weak in fibre. Value Rs. 300.

Sisodra Plot.

1	Selection I selected	Of the three samples, 1, 2 and 3, No. 1 is the best, No. 2 comes second and No. 3 comes last. Value them respectively at Rs. 320, Rs. 315 and Rs. 310.
2	1027 ALF II General	
3	Navasari Local	

Nadiad Farm.

1	Lalio	This cotton shows deterioration on Nadiad Farm. Value Rs. 260.
2	Cambodia	This also has deteriorated considerably. Value Rs. 275.
3	Bhuri	This also shows deterioration and is very irregular. Value Rs. 255.

Dhulia Farm.

1	Surat-like	It shows a great deal of improvement, the cotton being almost equal to Surat in length and strength of fibre, though not in feel and silkiness. Value Rs. 305.
2	Broach-like	This shows no improvement. It is very irregular. Value Rs. 275.
3	N. R. Cotton	This cotton has more the characteristic of Assam cotton and woolly in feel. The staple is short. Value Rs. 220.

Basis of prices on 27th June 1914:—

	Rs.
Broach	290
Madras Cambodia	330
Surat	315
Fine Bengal	215
Navasari	335
F. Dhollera	270

Kathiawar.—The following note was drawn up by Mr. Mankad, Assistant to Cotton Specialist, for the information of the Morvi State, which called upon us for special advice :—

“ The District resembles South America in shape; the average rainfall is 18 to 22 inches, very irregular in distribution which tells considerably upon the production of the cotton crop.

Soils.—There are three kinds of soils, *riz.*, (1) black cotton soil, (2) besar and (3) light. The last named is chiefly met with in the southernmost part of the State towards Tankara.

Rotation.—Cotton is rotated mostly with Jowari in cotton soils, but in lighter kinds of soils Bajri forms the principal rotation.

The average area devoted to the culture of cotton in the State varies from 1,25,000 to 1,40,000 acres per annum. Broadly speaking, on account of enhanced prices of cotton, of late, two-thirds of the total cropped area is annually put out under it, as it pays better to the grower. The average outturn may be computed at 100 lbs. clean cotton per acre. In recent years, however, it has become the general practice to grow cotton without any rotation whatsoever, on the same land, and it is held amongst the cultivators that there is no diminution in the outturn. Economically the practice has proved a sound one owing to the high price of cotton.

Varieties of cotton.—Practically speaking, there are only two varieties in the State, called (1) *Deshi* or *Wagad* (bolls of which are picked out bodily from the plant and the cotton extracted at home), and (2) *Kunri*, acclimatized Broach, the seeds from Kalnun of the Broach District seem to have been brought in these parts some 25 years ago; in addition to these two, there is a third variety called *Mathio*, mixture of all the *neglectum* types that compose the cottons of Khandesh and Central Provinces, which occupies a very small area in the south of the district towards Tankara.

and is grown in light soils only, to get the crop ready before frost occurs as this tract is more subject to it.

The actual area under each of these three varieties is not separately kept, but it is understood that *Deshi* or *Wagad* occupies the largest area. Of the two principal varieties, *Wagad* is raised purely as a dry crop, but *Kanvi*, wherever there are facilities for irrigation, is given two or three waterings; as an irrigated crop, it gives a larger return. *Kanvi* matures also three weeks earlier than *Wagad*, the picking of *Kanvi* cotton is easier than that of *Wagad*, as it bursts out from the capsules when the bolls ripen; in the case of *Wagad* cotton, however, the opening of the bolls is not perfect, so that the bolls are plucked off and cotton extracted at home, which entails extra expenditure.

Forty pounds of *Wagad* bolls give 28 lbs. of *kapas* after extraction. The charges for taking out cotton from the unopened bolls vary from one anna to three annas according to seasons. This work is mostly done by women.

There are three distinct cotton tracts in the State according to the quality of cotton produced.

(1) The eastern portion is known as the Nadipar, which is practically free from frost, the cotton produced in this tract is offered 4 annas more per maund than that produced in the Boidiar tract.

(2) The western portion is called the Boidiar tract (there are many *bor* trees, *Ziziphus jujuba*). This is partially subject to frost. The produce of this tract is considered inferior to that of Nadipar but better than that of the Tankara tract. In this tract *Wagad* cotton is pollarded. Cultivators believe that the yield and quality of the rattoned crops are maintained. This belief is incorrect. The ratton crop was valued at Rs. 245 per maund against Rs. 255 of the fresh crop of *Wagad*, the ratton crop is also bound to fall off in ginning percentage in addition to the quality of cotton. I am informed

that a large area is kept under the ratoon in this tract in order that the crop may be picked out before the frost occurs.

(3) The southern portion is known as the Tankara tract which generally suffers from the effects of frost. *Mathio* is, therefore, grown in lighter kinds of soils to get an early crop. As *Mathio* produces a very small crop, the produce is usually mixed up with two principal varieties already mentioned. The quality of cotton of this tract is considered inferior to that produced in the eastern and western portions.

With regard to the quality of cotton, I feel that both *Wagad* and *Kanvi* are equally good. The crops vary slightly according to seasons only.

Kanvi.—The staple is slightly longer, fibres weak, cotton dull in colour and thin.

Wagad.—The staple is slightly shorter, but strong and white in colour, in addition, the cotton is *bulky*.

Bulk for bulk *Wagad* cotton fetches on an average Rs. 10 more per candy than *Kanvi*.

Samples of both these varieties were obtained from each of the three tracts and were submitted to Messrs. Tata, Sons & Co. for opinion. The following are the valuations of each of these samples.

Basis of valuation on 6th May 1914 :—

	Rs.
Fine Broach	265 per candy of 784 lbs.
Morvi	250 , , ,

Nadipar tract.

<i>Wagad</i> from Jetpur	240
<i>Kanvi</i>	235

Boidiar tract.

<i>Wagad</i>	255
<i>Kanvi</i>	250
<i>Aroora</i> (ratoon)	245

	Rs.
<i>Wagad</i>	250
<i>Kanvi</i>	240

From the valuation report it will be seen that the quality of cotton of the Boidiar tract is superior, then comes the Tankara tract and lastly the Nadipar, which ought to come first. This is puzzling, but it may be capable of explanation. My own observations in these three tracts lead me to believe that in the Nadipar tract, cotton matures a little earlier than in the other two tracts and being adjacent to the Dhrangadhra State, should produce cotton of better quality. The same two varieties are being grown in the Dhrangadhra State and fetch Rs. 10 more per candy than the Morvi cottons in the Bombay market.

Selection of seed.—It is gratifying to note that the *kunbis* who form a majority of the agricultural class are exceptionally keen on selecting well-opened bolls and hand-gin the same for seed requirement. Seed for sowing purposes is never brought in either from the ginneries or from Banias' shops by the *kunbi* cultivators.

Seed for sowing is also carefully stored in earthen *chattis*.

Hand-gin.—This differs from that used in other parts of India (excluding Kathiawar). It is an ordinary gin to which a fly-wheel is attached. the price of such a gin depends on the quality of the fly-wheel, but it may be taken at Rs. 10 to Rs. 15. The work done by this hand-gin with the *herbaceum* types of cotton is 160 lbs. of *kapas* per day, working at the rate of 12 hours a day requiring two men and one woman.

In addition to ginning cotton for seed requirements, the *kunbi* cultivators take out sufficient seed for cattle for the year by means of such gins; a portion of the lint obtained is spun by hand for making clothes, ropes, etc., to meet domestic and agricultural requirements and the surplus is sold. The hand-ginned cotton fetches Rs. 10

less than the machine-ginned per candy, as the former contains comparatively a larger percentage of broken leaf, dirt, etc.

With regard to general cultivation, it should be mentioned that the *kunbi* cultivators are first class people in handling the land. The cotton fields were found scrupulously clean throughout and the agricultural operations perfect. The standard of cultivation could, however, be raised by deep-ploughing, etc.

As the rainfall is very precarious, it is suggested that a bullock-hoe of the Surat type (curved blade) for interculturing might prove more beneficial than the local hoe in the conservation of soil moisture. I have personally explained its advantages to the Revenue Commissioner and the Patel of Mandan. A blade of the Surat hoe has already been sent from Surat.

Varieties actually under trial.—In the Kesawala garden, trials were made in sample plots with five varieties including two perennial cottons, *riz.* :—

- (1) *Kumpta* (seed obtained from Miraj).
- (2) *Dharwar American* and *Cambodia* (Upland types).
- (3) Seed received from Rangoon (*Neglectum* types).
- (4) And with varieties of perennial cottons, *riz.* :—

Spence and *Kidney* or chain-seeded.

All these had received waterings.

- (1) *Kumpta*.—The growth was satisfactory, the crop had not ripened but a few bolls that had opened were examined; cotton was thin on seed, as is usually the case with this variety, though the quality of cotton was almost equal to *Kumpta* of the Southern Mahratta Country. The local cotton (*Wagad* or *Deshi*) is superior in all respects to *Kumpta*, as the percentage of cotton to seed is greater than the one under trial, and the cotton is also bulky.

(2) *Dharwar American* and *Cambodia*.—The former had practically failed, on account of the attack of leaf blight, the latter grew satisfactorily, branching in all directions. On examination the fibre was found weak and the staple comparatively short, though it showed high percentage of cotton to seed. This quality may fetch Rs. 20 to Rs. 25 more per candy over the local cotton.

These varieties were planted out too far apart (6 feet on either side). The American annual forms are grown in the same way as the local cottons, i.e., lines 2 feet apart and distance from plant to plant 1 to $1\frac{1}{2}$ foot in the row.

(3) *Seed from Rangoon*.—The resulting plants were of the *neglectum* type, the ripening period had considerably prolonged, probably due to irrigation. In parts where the *neglectum* types are grown, the crop requires five to six months only to mature. The quality of cotton is in no way superior to the local cotton; it should, therefore, be abandoned. This is something like *Mathia* cotton.

(4) and (5) *Spence and Kidney cottons (perennial varieties)*.—These had made very unsatisfactory progress. Results of a few years' experiments proved plainly that all the varieties of tree cottons possessed so many inherent defects that their profitable cultivation was impossible *on a field scale*.

Mr. Spence's attempts at the cultivation of *Spence* variety on a large scale at Deesa and Jamnagar, Mr. Tytler's at Belgaum with *Rough Peruvian* and Messrs. Shaw, Wallace & Co.'s in Bengal with *Carmonica* and almost all tree cotton varieties hopelessly failed and no one reports even moderate success with them.

The chief drawbacks in their cultivation are :—

(1) Their very structure is that of woods and sheltered places.

- (2) Their brittle nature forbids their being grown in open fields exposed to winds.
- (3) They are more subject than the annuals to insect pests and these are carried from year to year and the land becomes weed-infected.
- (4) And finally, the steadily decreasing annual outturn is the strongest argument against their cultivation.

In conclusion, it can safely be said that the tree cotton which will succeed in India as a *field crop* has still to be discovered and it is extremely risky to attempt the hopeless task of tree cotton cultivation on a commercial scale.

In the new garden, I was shown about half a dozen grafts that had been made between the *Arboreum* and *Deshi* cotton according to the new discovery by a German named Schætin. It has been suggested to collect all the cotton when the bolls ripen and to put out a larger area next season to test the results. In our opinion, it is highly probable that the cotton plant with its brittle wood and tough fibrous inner bark does not allow of any process of grafting, which will produce frost-resistant types possessing desirable quality of cotton.

I was taken over the proposed area of 2,000 acres in 3 blocks in the Tankara tract, which is to be left at the disposal of an American expert, whose services have been lately acquired, to test the suitability of various crops. Most of the land is under cultivation, flat, with facilities for irrigation, in fact, beautiful to work with and it is hoped that the authorities will spare no pains to tackle various points connected with the improvement of cotton.

I had also an interview with His Highness the Thakore Saheb of Morvi, who takes keen interest in the improvement of the cotton crop, and we discussed the cotton question at full length. He desired to try *Broach* seed, which has been supplied. As the rainfall is scanty, I am afraid that the long duration of growth required by *Broach* cotton might tell upon the opening of the bolls.

In conclusion, I think that the two local varieties *Wagad* and *Kanri* are in every respect suitable to these parts and the products meet the demand quite satisfactorily. As the conditions of soil and climate do not seem to favour any other variety, either Indian or foreign, I would suggest that attention should be directed to increase the outturn by better methods of cultivation and improve the ginning percentage of each of the two local varieties by selection. An attempt should also be made to distribute seed of *Wagad* and *Kanri* from the Dhrangadhra side, which produces better quality of cotton. At the same time arrangements should be made with the expert to test the suitability of Cambodia *under irrigation* and of imported Broach seed."

In this connection, the following letter was received from the Manager and Executive Engineer, Morvi State:—

"Mr. D. P. Mankad came here on the 3rd instant and stayed up to the 10th. He visited different Mahals of the State and made his journey on our tramway of a length of about 60 miles, where the principal crop is cotton. He was also shown the different varieties of cotton under trial in the State gardens. Thus every facility was given to him to visit the different parts of the State, so that he can send in his full report. I shall therefore feel very much obliged if you will kindly send me a copy of his report.

We are very much obliged to you for the help you have given us by sending Mr. Mankad, who was very busy here during his stay with his work and for this he also deserves our thanks in no less degree."

The Director of Agriculture, Baroda, submitted for valuation two samples of cotton grown in Kathiawar at Kodinar.

The first, of *New Orleans* type, was selected out of the prevailing mixture in the fields and grown separately to ascertain its value. The plot was flooded three times by heavy rain during the season. In spite of this a yield of 208 lbs. of seed cotton per acre was obtained, the ginning percentage

age being 30.3. The clean cotton was valued by Messrs. Tata, Sons & Co. at Rs. 315, compared with Sind American of the same date at Rs. 310.

The value of the second sample, which was a selected local *Mathio*, was Rs. 190, equal to fine *Mathio* of the day. No figures of outturn were supplied with this.

It has been suggested to the Director to repeat these trials during the present season.

Southern Mahratta Country.—The following notes were sent to the Director of Agriculture, Bombay, after an inspection of the cottons in the Southern Mahratta Country:—

“ Dharwar.—There are now series of 10 generations of *Broach* cotton on this farm. The percentage has dropped to 29, which is, however, about 4 to 5 per cent. higher than the maximum of *Kumpta*, so that, judged on this point alone, it still leads.

Some members of the local Agricultural Association have offered to grow annually 300 acres of *Broach* from imported seed and to guarantee the distribution of seed only from cotton of the first class from this area, the standard to be fixed when lots are ginned to ascertain the percentage. This seems to be the most practicable plan to ensure the continuous supply of selected *Broach* seed in the District.

The longer growing season of *Broach* would always be a strong factor against the possibility of its ever supplanting *Kumpta* in any great degree. By steady selection the ginning percentage in *Kumpta* has been raised to 29, an advance of 4. It is quite possible that, by steadily aiming for percentage, a still further increase could be arrived at.

The cultivation of *Cambodia* has been abandoned at Dharwar. The crosses between *Soft Peruvian* and *Cambodia* are not promising after all; they seemed to have retained the perennial character and may fruit if held over for another season. As perennial cottons have

been proved unsuitable for conditions in India, there seems no good ground to justify the maintenance of these crosses.

One hundred pounds of selected *Kumpta* seed have been given out, but no results are yet available. It has been proved that the use of a fence of *Shurri* as a wind break is not practicable, as it exercises a distinctly bad influence on contiguous crops.

As far as I could gather, there is no dissatisfaction expressed regarding the quality of the imported Navasari seed this year.

Gadag.—This farm is now restricted to trials with American types of cotton. As at Dharwar, the cross between *Cambodia* and *Soft Peruvian* is not at all promising.

The whole of the *Cambodia* is now treated as being one variety, and the trials are directed with a view of keeping up the standard of staple and percentage.

The two forms of *Dharwar American*, which were isolated upon my advice last year, have been grown with a high percentage of purity. There is still a doubt as to whether the Upland or New Orleans type is superior. I am informed that some of the villages producing superior Dharwar American cotton are said to grow the New Orleans type exclusively. I have suggested that a fresh survey of these types in the district should be undertaken.

The following valuations were kindly supplied by Messrs. Tata, Sons & Co. :—

Valuations.

Basis of prices on 11th June 1914 :—

	Rs.
(1) Navasari	335
(2) Surat	320
(3) Madras Cambodia	310
(4) Kumpta	290
(5) Fine Broach	285
(6) Sawginned	265

Serial No.	Registered No.	Name.	Valuation.
<i>Dharwar Farm.</i>			
1	1027A	Kumpta X Ghogari (Surat Cross)	We place them in the following orders as regards length of staple and general quality: first No. 2, second No. 3, third No. 4, and then No. 1. Of Nos. 5 and 6, No. 5 is better than No. 6. We value:—No. 1 Rs. 305, No. 2 Rs. 325, No. 3 Rs. 320, No. 4 Rs. 305, No. 5 Rs. 300, No. 6 Rs. 295.
2	1361	Do. Dharwar Cross old	
3	2603	Do. Dharwar Cross new	
4	1339	Kumpta Cross	
5	...	Kumpta selected for quality	
6	...	Do. for quantity	
7	...	Broach, 1st generation (new seed)	Of these, No. 8 is the best. No. 7 comes next and rest are almost all more or less equal, though we find that Nos. 13, 14 and 15 are a little better than Nos. 9, 10, 11 and 12. We value:—No. 7 Rs. 310, No. 8 Rs. 315, No. 9 Rs. 300, No. 10 Rs. 300, No. 11 Rs. 300, No. 12 Rs. 300, No. 13 Rs. 305, No. 14 Rs. 305, No. 15 Rs. 305.
8	...	“ 2nd ”	
9	...	“ 3rd ”	
10	...	“ 4th ”	
11	...	“ 5th ”	
12	...	“ 6th ”	
13	...	“ 7th ”	
14	...	“ 8th ”	Compared with No. 28, No. 7 is superior to it in length of staple, and is rather thin.
15	...	“ 9th ”	
16	2016	(Old seed introduced in 1904.) Kumpta X Comilla	The crossing has materially improved in the length and strength of staple over Assam. There seems to be no deterioration. If anything, it has improved. Value Rs. 285.
17	1027A	Kumpta X Ghogari	In crossing, it has obtained white colour of Ghogari and in staple it is ordinary Kumpta. Value Rs. 290.
18	1339	Kumpta Cross	It seems to have improved. Value Rs. 300.
19	...	Kumpta ordinary	Compared with Nos. 1 to 6, there can be no comparison with them, since both are very inferior as regards length and strength of staple. Of the two, No. 19 is superior to No. 21 which is even weaker than Kumpta in the local market. Value No. 19 at Rs. 280, and No. 21 at Rs. 260.
20		“ ” from plot 608	

Serial No.	Registered No.	Name.	Valuation.
20	102E	Cambodia	The cotton is very weak in fibre and irregular in length. Value Rs. 280.
22	...	Cultivator's Kumpta	It is no way superior to ordinary Kumpta, equal to local cotton. Value Rs. 290.
<i>Gadag Farm.</i>			
23	...	Dharwar American (Green-seeded)	It is better than ordinary Sawginned coming in the local market. Value Rs. 280.
24	120E	Cambodia	This cotton seems to be little better than No. 20 of the Dharwar Farm, but still it is weak in fibre. Value Rs. 300.
25	1345	Christopher X Christopher	It is longer in staple than No. 24, but equally weak. Value Rs. 310.
26	1356	Christopher X Culpepper	This is a very long stapled strong fibred cotton. Every way a desirable stuff. Value Rs. 360. This deserves to be widely cultivated.
27	...	Dharwar American (Gadag Market sample)	This seems to be a mixture of Sawginned and Kumpta kapas. Hence there seems to be some strength in the fibre. Otherwise the cotton is of very inferior quality. Value Rs. 260.
<i>Gokak Farm.</i>			
28	...	Broach New seed	It is slightly inferior in length of staple than Navasari. Value Rs. 320.
29	1339	Kumpta Cress	It has improved in every way. Value Rs. 295.
30	...	Kumpta Ordinary	It has lost in length of staple. Value Rs. 285.
31	102E	Cambodia	It has entirely deteriorated on the Gokak Farm. Value Rs. 275.
32	...	Cultivator's Kumpta (Arbhavi)	It is better in length than farm Kumpta No. 30. Value Rs. 290.

Of four crossed cottons, *Kumpta X Ghogari* (Dharwar Cross old) was valued at Rs. 325; *Kumpta X Ghogari* (Dharwar Cross new) valued at Rs. 320; *Kumpta* Cross valued at Rs. 305; *Kumpta X Ghogari* (Surat Cross) valued at Rs. 305.

Kumpta selected for quality was valued at Rs. 300 and the same selected for quantity at Rs. 295. The samples of *Kumpta* ordinary cotton were valued at Rs. 280 and Rs. 260, thus testifying to the far higher value of the improved varieties given above. A sample of cultivator's cotton from Dharwar was valued at Rs. 290, equal to local cotton. Another *Kumpta* Cross was valued at Rs. 295. A sample of cultivator's *Kumpta* from Arbhavi was valued at Rs. 290. A sample of *Cambodia* from Dharwar Farm, where the conditions are unsuitable for it, was valued at Rs. 280 only, on account of its weak and irregular fibres; even a sample from the Gadag farm, where the conditions are far more favourable, was valued at Rs. 300 only. Green-seeded Dharwar American from the Gadag farm was valued at Rs. 280. A market sample from Gadag seemed to be a mixture of *Dharwar American* and *Kumpta*. It was valued at Rs. 260. Of the Upland Crosses, that of Christopher X Culpepper seems to hold the first position in value. Messrs. Tata remarked that this is a very long stapled, strong fibred cotton and, in every way, desirable stuff, which deserves to be widely cultivated. They valued it at Rs. 360.

Of the 9 generations of Broach cotton at the Dharwar Farm, Messrs. Tata valued 2 at the best, 1 as the second, and the rest more or less equal, though they found 7, 8, 9 a little better than 3, 4, 5, 6. Last year, it appeared that the deterioration was continuous, but, from this year's figures, it would appear that after thorough acclimatization perhaps an improvement may set in.

The auction sale of Broach Cotton.—The auction sale of Broach cotton was held at Dharwar on the 12th April 1914. In all 80,000 lbs. seed was distributed during the

year 1913-14 (30,000 lbs. seed imported from Navasari and 50,000 lbs. locally grown Broach cotton seed).

All the seed was not sown for want of timely rains, the approximate area sown would be between 4,000 and 5,000 acres.

Sowing commenced from the end of June to middle of July.

Season on the whole was not favourable either to Broach or to local cotton *Kumpta*.

There were no late rains and consequently cotton plants suffered.

In all 3,500 *dhokras* of *kapas* were received (4 *dhokras* are equal to 1 *Naya*, that is, equal to 1.344 lbs.) at the auction Depôt. I am informed by the Agent of Messrs. Tata, Sons & Co. that more than 300 *Nayas* were sold away by the cultivators before the auction sale for immediate requirement of money.

Broach cotton at the Depôt was graded in six classes according to ginning percentages.

The following prices were realised per *Naya* of 1.344 lbs. :—

Class.	Ginning per cent.	Price.
Special class	34 and above	190
I	33.5	185
II	32.5	176
III	31.5	175
IV	30.5	171
V	29.5	155
Kappta Cross	27.5	139

The rate of the local cotton *Kumpta* on the day was Rs. 129 per *Naya*.

The low ginning percentage may be due to (a) the deterioration of the local cotton seed, (b) poor ginning percentage of the last pickings.

The representatives of the Bombay mill-owners and the local merchants who attended the sale were thoroughly pleased with the quality of cotton and believed that the stuff was similar to Navasari cotton except that the staple was rather rough and added that there will be no difficulty in realising good prices for this class of cotton up to 10,000 *Nagras*, and wished that the cultivation of this cotton should be extended.

There were no complaints regarding the quality of seed, but it is absolutely necessary to renew every year a large quantity of Navasari seed to keep up the standard of staple and ginning percentage.*

It is interesting to know that a man who had put out only 6 acres under *Broach* cotton, realised Rs. 574 at Rs. 95 per acre.

Cambodia Cotton.—The cultivation of this cotton has been tried in so many diverse localities that it is as well to collect all our scattered references under one head.

Guzerat.—Mr. Mankad has supplied the following note on Cambodia prospects in North Guzerat as the result of his inspection in November last :—

“ Believing that the cultivation of *Cambodia* must have spread at Bawla. I went there on the 9th November, when I was informed that the cultivation was not undertaken during the present year.

The glowing report on this cotton is said to have had some effect in a village called Vasna in the Dholka Taluka and it is reported that a few acres have been put under this cotton. It is a fact that *Cambodia* seed in these parts was sold at an enhanced rate, 5 to 6 rupees per maund of 40 lbs.

* The ginning percentage this year, on the whole, seems to be high throughout.

The details of the three methods of cultivation of both *Bhuri* and *Cambodia*, in the Goradu soil on the Nadiad Farm are as follows:—

- (1) Start given by two waterings from May.
- (2) Rain-fed.
- (3) Two waterings to be given after the cessation of rains.

The new exotics were found attacked by wilt and aphides. White-ants had also destroyed a good many plants. Judging from the growth of the plants, the local cotton, *Lalio*, appeared more promising. *Bhuri* seems to be hardier and earlier in ripening (3 weeks) than *Cambodia*, but the low outturn combined with a low ginning percentage and a weak fibre are the greatest objections to it.

Cambodia tried at Shahpur near Petlad and at Cambay in the Kaira District also suffered from the attacks of leaf-rollers and aphides. The experimenters now report that the outturn is disappointing.

I am inclined to think that the following points do not seem to appeal in favour of *Cambodia*:

- (1) During the very first year of its trial in 1912-13 it gave a decidedly low ginning percentage on the Farm, and it seems doubtful whether it will keep up both in quality and ginning percentage; these two factors are of vital importance in the successful cultivation of cotton.
- (2) Being a delicate variety, it is more susceptible to insect pests than the local cottons.
- (3) Unless cultivation extends fairly on a large scale there seem small prospects of establishing a market for the disposal of this kind of cotton. It is also a question how far the product will be kept thoroughly pure.
- (4) It seems difficult in practice to start the crop under one or two waterings in May to get good returns.

Irrigating the crop after the cessation of rains is likely to prolong the period of maturity."

In the Cambay State, 4 acres were put out, yielding at the rate of 140 lbs. seed cotton per acre. The sample of the clean cotton was submitted to Messrs. Tata, Sons & Co., who remarked that "the cotton seemed to be carelessly picked and ginned. It has retained the length of fibre and silkiness. We value it on Dhollera Basis Rs. 10 below Dhollera at Rs. 250. We may mention that if it had been carefully picked and ginned, it would have fetched Rs. 265 per candy."

In the Kaira District, at Shahpur also *Cambodia* was given a trial. The crop suffered badly from insects and no outturn figures were supplied, but the sample of the product was valued at Rs. 270. *Cambodia* on the day being at Rs. 290.

Dhrangadhra (Kathiawar).—Half an acre of *Cambodia* from seed supplied by us yielded 12 maunds and 30 seers (510 lbs. of seed cotton), as an irrigated crop, whereas *Kanci* local cotton yields 10 maunds (equal to 400 lbs.) for half an acre in open fields; a mill-owner estimates that *Cambodia* would fetch 16 per cent. more than the price of the local cotton. A sample of this *Cambodia* cotton was reported on as follows by Messrs. Tata, Sons & Co.:-

"It is out and out superior and is the best *Cambodia* of the samples examined to-day. We value it at Rs. 320. equal to Navasari and Rs. 5 over the basis of Madras *Cambodia*."

Further trials are to be made this season in dry land.

The auction sale of Cambodia cotton.—The auction sale of *Cambodia* cotton took place on the 19th April at Gadag.

The area under this cotton was much limited during the year owing to its failure during the year 1912-13.

Purified Madras seed was distributed in the Gadag and Ron Talukas of the Dharwar District.

About 500 to 600 acres were grown under *Cambodia*. Sowing took place in the middle of September. The season was not favourable to any class of cotton and I am inclined to think from personal observations that *Cambodia* comes out well in a *bad season*.

In all 587 *Dhokras* (4 *Dhokras* make one *Naga* of 1,344 lbs.) were received at the auction Dépôt.

The cotton was graded in 6 classes according to ginning percentages and realised the following prices per *Naga* of *kuppas* (1,344 lbs.) :—

Class.	Ginning percentage.	Price.
Special Class purified	37 and above.	Rs. 196
I	36.5	187
II	35.5	189
III	34.5	177
IV	33.5	172
V	32.5	168

Except the special class other classes may have an admixture of *Uppam* and *Karunganni* plants to a small extent and this may account for slightly low ginning percentage.

The local cotton *Dharwar American* on the day stood at Rs. 126 per *Naga* of 1,344 lbs.

N.B.—The cotton was perfectly clean but harsh to touch, staple also shorter than the standard of *Cambodia*.

The cotton of the special class was thoroughly purified by the Department and it is intended to distribute seed of this class only, together with that received from the Gadag Farm.

On the whole, the auction sale was a great success and *Cambodia* fetched very satisfactory prices. It is possible that the cultivation will considerably extend during the ensuing year.

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Messrs. Tata, Sons & Co. have kindly furnished the actual valuations of all the five classes :—

Special Class	Rs.	
	275	
I	280	
II	290	
III	270	
IV	285	

Being ginned not in ordinary gins but in sawgins, the staple seems to have been cut and cotton presents a happy appearance. We value them on the basis of the value of sawginned at Rs. 270.

Basis on 17th July 1914 :—

	Rs.
Madras Cambodia	315
Sawginned	270
Navasari	320
Kumpta	275

From the valuations, it will be seen that the trade appreciate the ginning percentage and not the quality so much.

As in former years, I have to thank Messrs. Tata, Sons & Co. for the care and trouble they have taken in furnishing valuations of the numerous samples of cotton submitted to them.

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III.—PROGRAMME OF WORK FOR THE YEAR 1914-15.

(1) To visit and advise on points regarding cotton and its cultivation whenever requested to do so by Provincial Departments of Agriculture.

(2) The study of the behaviour of *Bourbon*, *Bhuri*, *Cambodia* and other such cottons in non-cotton-producing tracts, as detailed in the last year's programme, will be continued.

(3) An enquiry on the manurial requirements of cotton will be continued.

(4) Researches on the botany of cotton will be continued.

